A PICTURE BOOK OF EVOLUTION

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OF

EVOLUTION

BY

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PART I.

CONTAINING LESSONS FROM

ASTRONOMY—GEOLOGY—ZOOLOGY

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INTRODUCTION

The history of our forefathers is the history of ourselves. Any intelligent child of ten can now learn more of the history of the world and its inhabitants than all the wise men of the earth could have taught his grandfather. The discoveries of science during the last fifty years have opened out a new world, and in that world we learn not a little of the life and origin of our forefathers. We can now look back through millions of years upon the formation of the earth and the coming in of its inhabitants. When *An Easy Outline of Evolution* was published, I was invited to produce a still simpler statement of the discovery of Evolution. Since then I have prepared six lantern lectures on the subject. In the two parts of this *Picture Book* all the slides of the lantern lectures are produced, and some new pictures have been added. Many additional facts are also given. It should be distinctly borne in mind that this *Picture Book* is for those who have *not* read any statement of the doctrine of Evolution. It is a first book for young people and those who have not much time to read. There are many excellent books on Evolution, but, owing to their difficulty or their cost, they are entirely shut off from thousands who wish to learn the facts brought to light by this great discovery. It has been well said: "Unless you understand Evolution you do not get all your facts, and you do not get the key to your facts." Perhaps it is scarcely possible to exaggerate the importance of giving the children in our schools some systematic course on Evolution; and

when knowledge is held to be better than ignorance, such teaching will be given. In the meantime, while we wait for the centuries to pass, this simple little statement is set forth to meet the wants of those who know that a great discovery has been made, and who wish to understand some of its first principles. I am not able to find a work by any living zoologist or other man of science in which it is said that Evolution is not true. And when thousands of men who have given all their lives to studying nature agree upon a great point like this, we may feel pretty certain that that point is true. All the main facts and arguments in support of Evolution are accepted as true by every man of science; and at present there is no other explanation of the earth's history and of the origin of mankind. Of course, it requires some effort of thought to understand this branch of science; but, when we do understand it, a new joy is added to life, and many of our greatest difficulties are cleared up.

My warmest thanks are given—(1) To Messrs. Chatto & Windus, the publishers of *Popular Astronomy*, by Flammarion and Gore, for kindly allowing me to reproduce so many plates from their excellent book, published at 10s. 6d. (2) To Mrs. Romanes, for permission to reproduce seven illustrations from her late husband's *Darwin and After Darwin*, 3 vols., 26s. Professor Romanes has given a clear and masterly account of Evolution. (3) To Professor Lapworth, of Birmingham, for giving me permission to reproduce many plates from his *Intermediate Text-Book of Geology*. (4) To Messrs. Campbell-Gray, who kindly allowed me to reproduce "Consul, the man-monkey."

DENNIS HIRD.

Bletchley, Bucks, August 23rd, 1906.

Chapter I.

SIMPLE EXAMPLES

If we wish to know how the earth was formed, and how all the plants and animals came upon it, we must let the men of science teach us the wonderful things which they have found out.

For thousands of years men have been inquiring into the history of the earth and all its inhabitants, and they have discovered very marvellous things.

One of these great discoverers was Charles Darwin. He and Alfred Russel Wallace separately discovered the same great principle of Evolution. This principle is called Natural Selection.

Darwin and Wallace published a short account of this in the journal of the Linnean Society on July 1st, 1858; and Charles Darwin's great book, *The Origin of Species*, was published on November 24th, 1859.

The publishing of this book was one of the greatest events in the history of mankind, for it has altered the thoughts of the world and killed many errors.

We are now able to look at the world and all "that therein is," and see pretty clearly how it has all come to pass. The whole process is called Evolution, which exactly means unrolling. With regard to living things—plants and animals—Evolution teaches that they all have come by descent from small early forms which were so

simple and tiny that no one can say whether they were plants or animals. We shall see some of these little things; they were probably partly plants and partly animals; they lived millions of years ago, before they had divided into the two classes we call "plants" and "animals," each of which has developed on its own line.

In the history of our earth there is nothing more wonderful than the fact that man has discovered so many of the laws by which the earth and its inhabitants are governed. If we begin with quite simple cases, we shall be able to see for ourselves the working of some of these laws.

This acorn is of the kind from which grow our oak trees. If I were to ask anyone to bring a party of friends and sit under the shadow of this acorn, I should cause much laughter. But if we could wait 500 or 1,000 years, till the acorn had produced a full-grown oak, nothing would be more natural than to seek shelter under it on a warm summer day. This teaches us one of the great laws of the world—namely, the law of growth. There was a time when a very little child could carry the acorn and the germ within it; but after centuries of growth it becomes so large that the strongest animal in the world could not carry it. If we are to understand how all the living things in the world have come, we must always bear in mind this law of growth.

FIG. 1.—An Acorn.

From a speck of matter so small that we cannot see it without a magnifying glass there may arise (by gradual growth) a giant tree or a huge animal. Let us take a familiar object—the bicycle—and we shall discover another law.

Fig. 2 shows us the nearest approach to a bicycle, such as men used in 1819, the year in

FIG. 2.—The Velocipede or Hobby-horse.

which John Ruskin was born. If men were to use it now, we should laugh, for it seems so grotesque. The rider pushed the machine with his

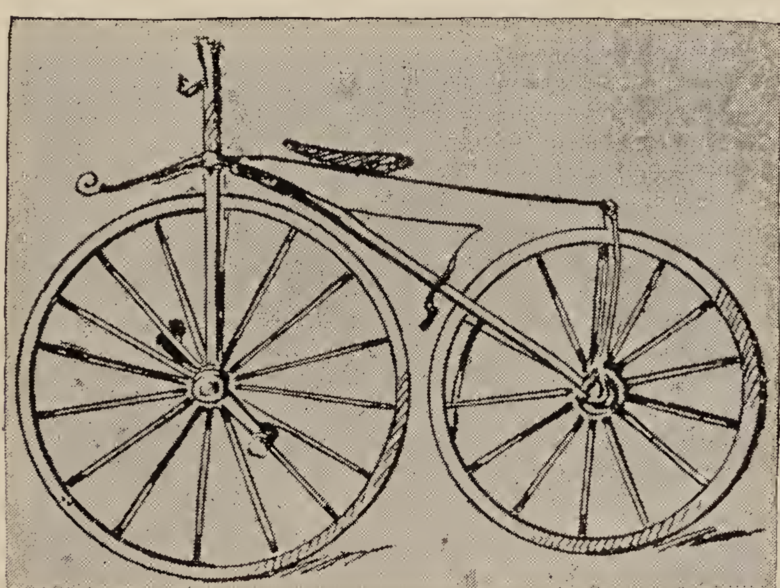


FIG. 3.—The Bone-shaker, a Bicycle.

toes, and then rode as long as he could before he gave it another push.

But improvements were made, and nearly fifty years after men used the old "bone-shaker," which you see in Fig. 3. It was an instrument of torture, without such luxuries as gearings or ball-bearings or pneumatic tyres; but it had pedals, and it was not a plaything. It was a great advance on the velocipede.

After the bone-shaker had been in use a long time, someone made an improvement, and men rode the "Humber Spider." This machine had an immense fore wheel, as you can see in Fig. 4, and

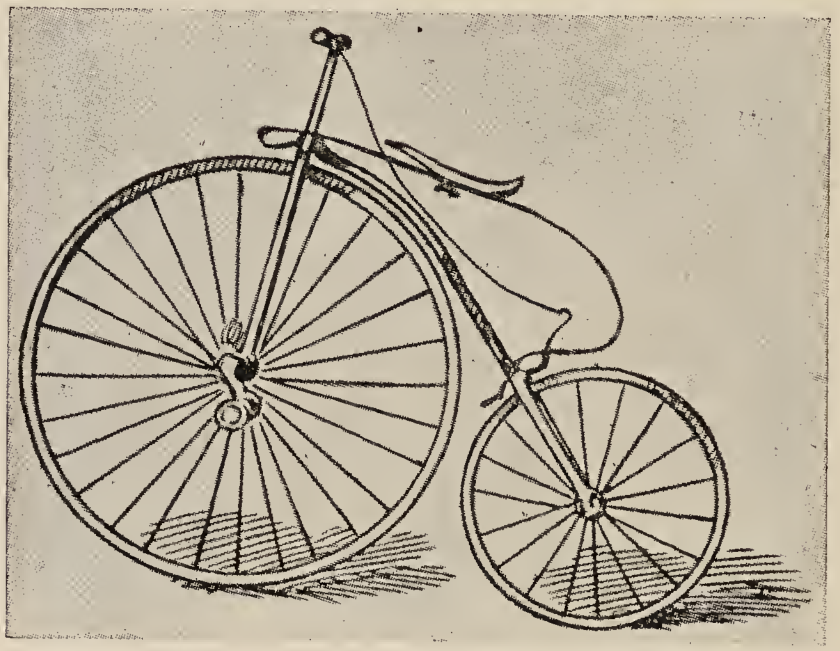


FIG. 4.—The Humber Spider.

a very small back wheel. The rider had to mount by steps, and to us it would seem not only dangerous, but absurd. Still, men had no better idea then.

But every year showed improvements. One found out that we need not have a huge wheel in front, with a sort of little lap-dog running behind; another thought of ball-bearings; another of the cushion tyre, and then of the pneumatic, and so on, till it was possible to buy a free-wheel, such as you see in Fig. 5, which not only is most beautiful and

comfortable, but saves a great deal of work whenever there is the least incline in the road.

Then the inventors caught up the idea of riding

FIG. 5.—The Free-wheel.

without hard toil, and produced the motor-cycle, as shown in Fig. 6.

On this machine it seems as if the rider glided along by a wish. The motor-cycle is of great

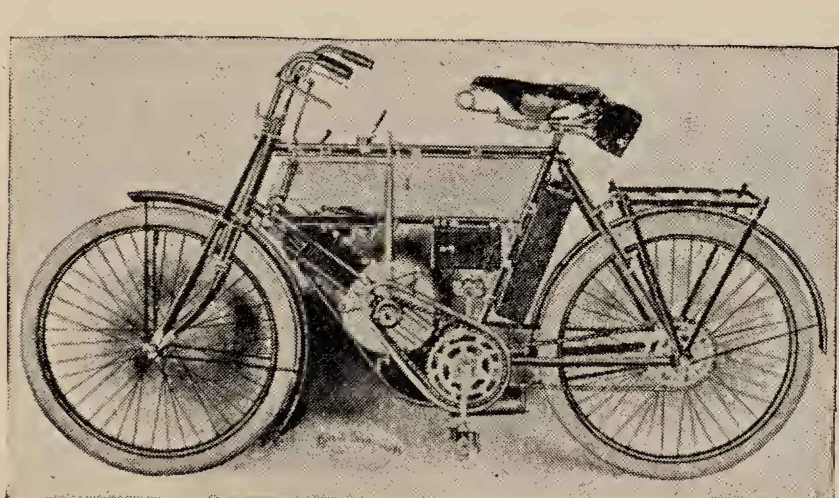


FIG. 6.—The Motor Cycle.

importance in the history of machines, for here men had discovered an easy source of motion, which enabled them to construct the motor-car.

In this machine the rider can abandon the

uncomfortable seat of the cycle and view life from an armchair, unless he travels so fast that he cannot clearly distinguish one object from another.

Now, I have taken these few examples of machines, with which everybody is familiar, and the first inventions of which are within the memory of some now living, because we have a very difficult task before us in the great facts of Evolution.

The account I have given of the bicycle might be called a short history of the evolution of the bicycle, and it has given us much to think about. Some of the steps of this evolution are clear to us :—

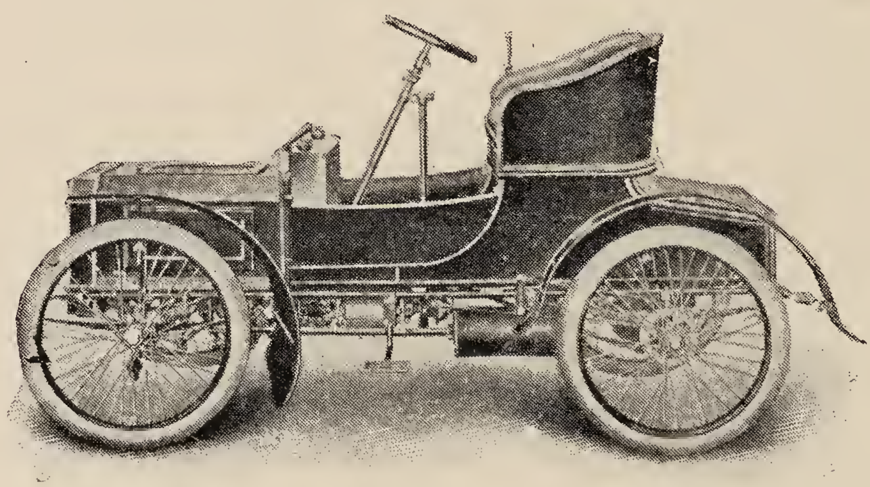


FIG. 7.—The Motor Car.

1. The earliest form was so simple and rude as to be almost useless, so that form did not remain long.

2. The improved machines drove the others out of use.

If you were to try to buy a hobby-horse or a bone-shaker, you would soon learn that they are no longer in the market, and probably in most towns you would not find one at any price. The steady march of improvements has banished them. This is what we mean when we say anything has become extinct. In a practical world the better banishes

the inferior. It is indeed a form of "the survival of the fittest."

3. We see in the motor car that, though there is the same motive-power, we have a very different kind of machine. It is the same principle differently applied.

These three laws are of great importance, and we shall meet them all again in considering Evolution.

FIG. 8.—Savages armed with bow and arrow.

After the very familiar steps shown by the bicycle, we may take another example.

In Fig. 8 we see a weapon which seems to us to belong so entirely to the past that it has left no trace in our modern life. Yet this is not so. Men probably lived many thousands of years before they discovered this deadly weapon. It was a marvellous

discovery in its time, but now you can find no soldiers armed with bows and arrows in the British army. Even a Royal Commission on army reform does not recommend their use!

I give this figure here for a very different reason. The bow and arrow gave rise to two wonderful inventions of our modern life; we see them in Fig. 9.

Few people at first see any connection between a

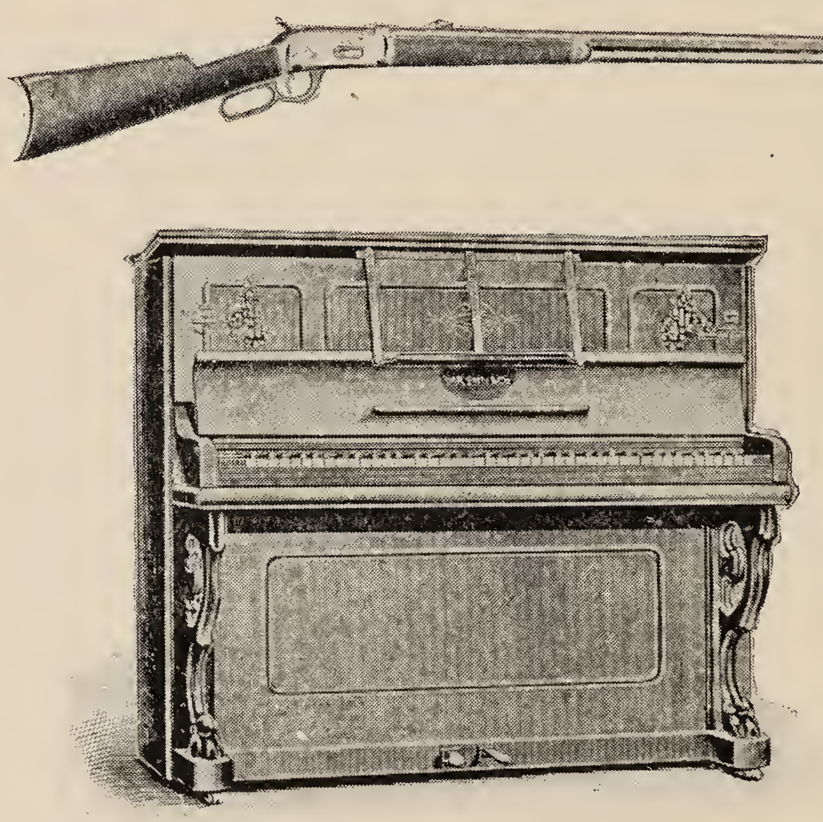


FIG. 9.—A Rifle and a modern Piano.

piano and a rifle. They are a fine example of the third law shown by the motor car; but two different principles have been developed from the same weapon.

When the hunter or warrior pulled the string close to his ear, he heard a rich twang as the string vibrated. So he began to develop instruments for producing sound by arranging two or three strings in a simple way. For ages these were improved,

as we have seen the bicycle was improved, till at last we have our modern piano—an arrangement of strings.

But a sterner use of the bow and arrow was to kill. Man is a killing animal. He improved the arrow and added strength to his bow, till the English archers were the dread of their foes when they used the improved long-bow. The invention of gunpowder gave a new force for driving a projectile, but the notion was the same as the driving of an arrow. The earliest guns were simple, and many improvements were made to give us the perfection of a modern rifle or a Gatling gun. The steps of the evolution of the rifle from the old Brown-bess to the modern weapon can be seen in the Pitt Rivers' Museum at Oxford.

Now, it must be granted that evolution is the true law in bicycles, pianos, and rifles; yet the critic may ask, "Is there any such process in nature to be seen in the known history of living things?"

There is.

We may begin with the simple well-known example of the horse's foot.

The feet shown in Fig. 10 tell one of the marvellous stories of the world. The hind foot is on the right and the fore foot is on the left in each pair. These are copies of the celebrated fossil feet found by Professor Marsh, and stored in the Yale Museum.

When any once living thing has been preserved in the earth or rocks it is called a fossil. In its simplest meaning a fossil is a thing dug out. These fossil feet were found in New Mexico.

I will deal with the fore foot only—*i.e.*, the one on the left hand in each case.

Beginning at the left hand of the figure, and

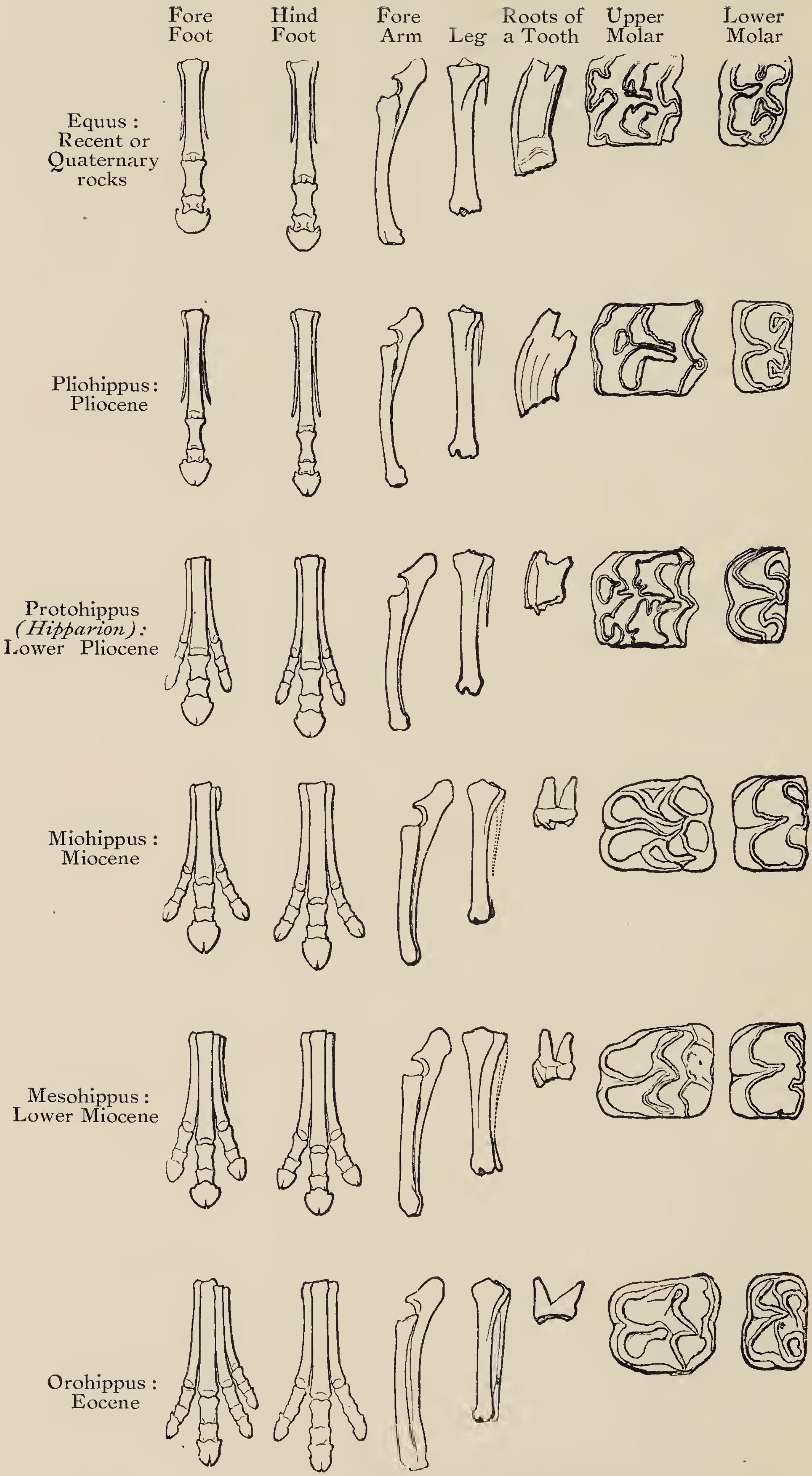


FIG. 10.—Six pairs of Horses' Feet.

working from the top, we see the large one toe of the horse as it is now, found in the bed of rocks called Recent,[1] and you should notice that on each side of this one large toe is a thin bone towards the top; these are the splint bones, and are all that remains of the two toes, which earlier horses once had.

These bones are found by digging a short distance down into the rocks; but by digging deeper down the foot second from the top of our figure was found. In this foot you see the splint bones are longer, or, as we say, more developed. This was found in the bed of rocks called Pliocene, and so the animal was named Plio-hippus (*hippus* is the Greek word for horse).

Still digging down lower in the same bed of rocks, there was found the foot third from the top, showing three toes. This animal was called the Proto-hippus, which means the first horse, but it was not the first. An ancestor of the horse remarkably like it, found in Europe, is called Hipparion. (See Chapter III.)

Digging down into another layer of rock named the Miocene, they found the foot fourth from the top. You can see a little knob of bone on the right at the top, which is a small trace of a lost toe, answering to the little finger of the human hand. This animal was called the Mio-hippus.

The next discovery found lower in the same bed of rocks is the Meso-hippus. In this foot the little knob of bone has become longer, nearly like the splint bone.

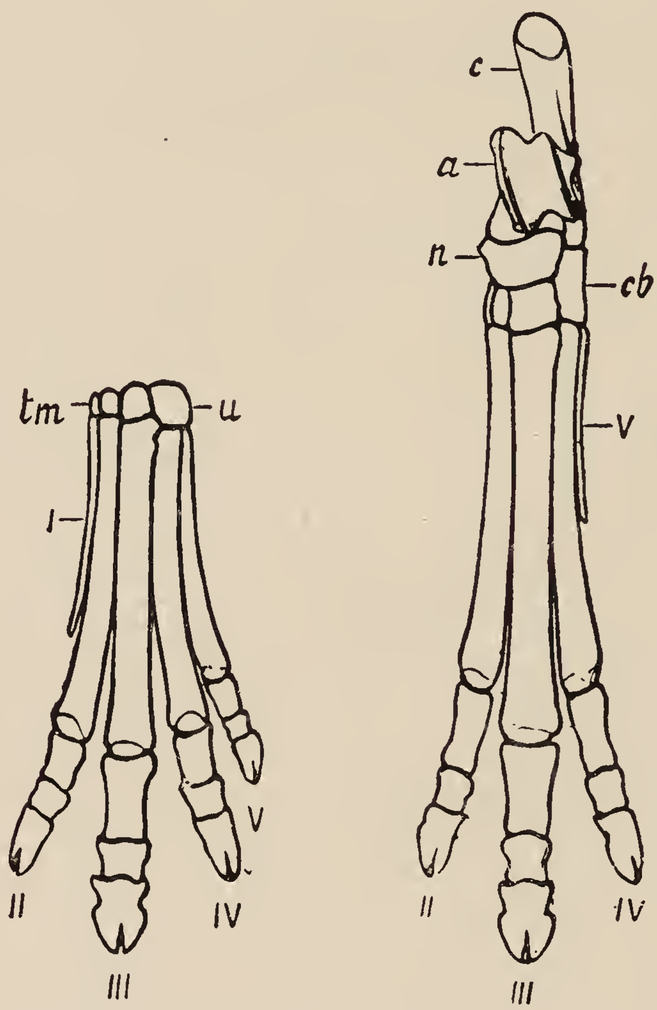
In the next layer of rock, named the Eocene, was found a foot with four toes (the Oro-hippus, which

[1] See pillar of rocks, p. 73.

means mountain horse). This animal was hardly as big as an ordinary fox.

Here the series of these wonderful discoveries was supposed to stop; but by digging in the lowest layers of the same bed (the Eocene) they found the remains of a still older animal of the horse series (the Eo-hippus), which has not only four toes,

Fore Foot



Hind Foot

FIG. 11.—Foot of the Eo-hippus.

but a remnant of the first toe, as you can see in Fig. 11.

This first toe corresponds to our thumb, showing that the animal came from a five-toed race. This animal was about the size of a very small fox.

Probably the whole race of horses is descended from an animal about the size of a rabbit.

Fig. 11 should be placed at the bottom of Fig. 10 to complete the series so far as known at present. If you refer to the pillar of rocks, you will see the various layers in which all these fossil feet of the horse have been found.

We are so accustomed to the big hoof of the horse that we are apt to forget that this hoof is only the large overgrown nail of the middle finger. In several recent cases horses have had divided hoofs, as you see in Figs. 12 and 13.

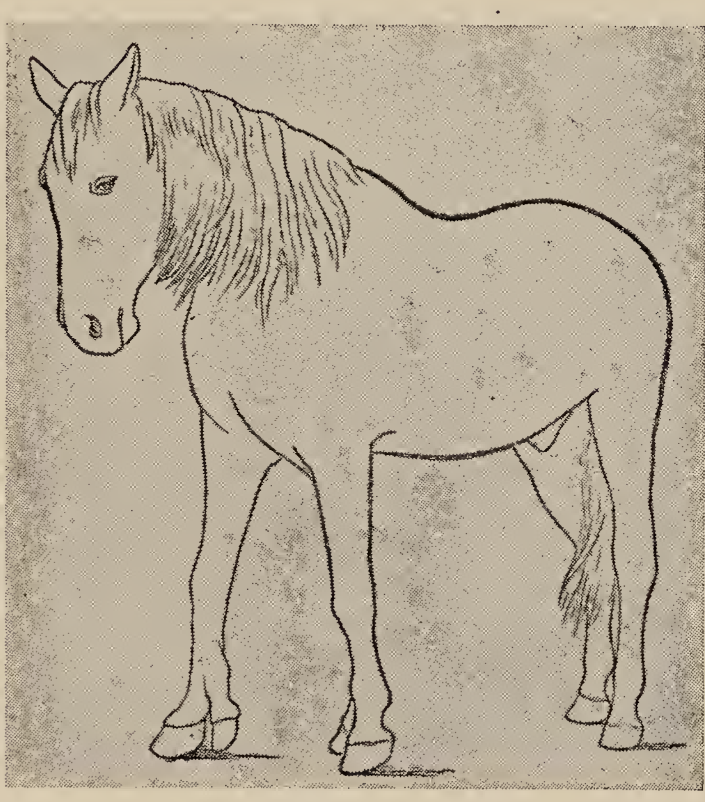


FIG. 12.—Horse with two divided hoofs.

These cases, together with the fact, to be considered later, that the very young foal, long before its birth, has three toes, are taken as further proofs that the horse has evolved from an ancestor which had, and used, more than one toe.

Further light is thrown on the ancestry of the horse when we consider the order of animals to which the horse belongs.

All hoofed animals are put together in one order,

and are called *ungulates;* this word comes from the Latin *unguis*, a finger-nail. Among these ungulates there are some remarkable forms, but the horse is the only animal that walks on *one* toe.

One of the oldest of this class of ungulates is the tapir, found in America, and shown in Fig. 14.

We know from geology that this order of ungulates (hoofed animals) comes from much smaller forms.

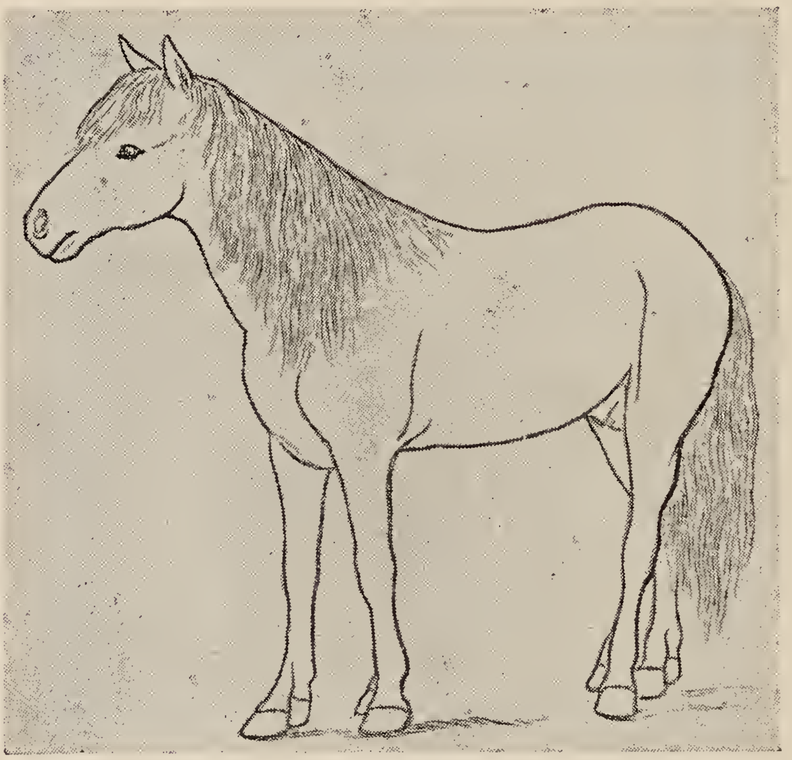


FIG. 13.—Horse with all its hoofs divided.

This order contains the hyrax, elephant, tapir, rhinoceros, horse, hippopotamus, pig, camel, cow, etc.

To realise that these large hoofed animals have come from smaller ancestors, you should study well the Cape hyrax in Fig. 15. At the Cape they call it "Dasee," and it runs in and out of their houses. It is sometimes called a coney. Many people think it is a sort of rabbit, and no wonder; but the ears, as well as other marks, show it is not.

This little animal looks rather like an overgrown rat, or, perhaps, reminds you of a guinea-pig (Cavy); but it is of amazing interest. For hundreds of thousands of years it has remained almost unchanged. It is the nearest living representative of the primitive ancestor of the elephant, the horse, the cow, and even the woolly mastodon.

There are fourteen species of this animal still living.

It is literally a walking museum; and perhaps

FIG. 14.—The Tapir.

only two *living* animals (the duck-mole and the sphenodon) are of equal interest.

Though its skeleton shows clearly the points of the hoofed-animal class, yet some of its teeth are like those of a rhinoceros, others like those of a rabbit or rat, and between these two extremes of teeth are some intermediate forms. The intestines of this animal tell a most ancient story, for it has paired caeca—*i.e.*, two blind guts—and in this structure it resembles birds. When we remember that mammals came from reptiles before birds

left reptiles, this structure, common to both birds and all the Dasees, carries us back into a lost eternity of life-history.

Now, when any animal has points in common with many other animals of distinct groups, it is called a generalised form. This coney is a fine example of a generalised form, and it is most important that we should learn exactly what is meant by this term; for a generalised form gives rise to many varieties, and may be said to be the parent from which different species spring.

Generalised forms, also, usually become extinct and lost, for they cannot hold their own in life's

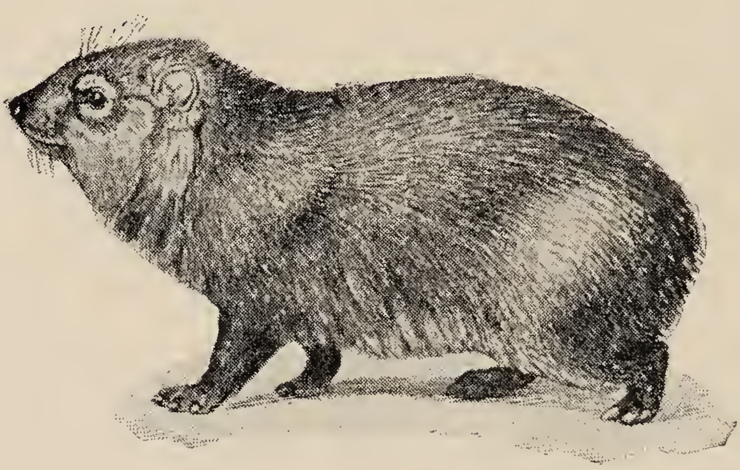


FIG. 15.—The Cape Hyrax or Dasee (a Coney).

struggle. In this world it is sometimes the specialist that succeeds. The horse is a highly specialised form.

Now let us pause and see what we have got, so far.

First, we have seen, from considering the acorn, that a small thing which a mouse can carry becomes, in the course of 500 or 1,000 years, so large as to shelter scores of people from the sun. All it needs is growth and time.

Second, we learnt from the bicycle that we get simple, imperfect forms first. We learnt the same

thing in the development of the horse's foot. It began in the small animal with the generalised form, having five toes; but, by specialising for thousands and thousands of years, it threw off all but the middle toe, and became that most highly-developed animal, the horse, with one very large toe.

Third, we learnt, also, from the ancestors of the horse that small animals of a generalised form can give rise to many different kinds of large animals in the course of ages. Nothing can be plainer and nothing can be more wonderful than that the horse, the elephant, the camel, and many others, have sprung from a group of very small animals, such as the coney, which looks almost like a large rat.

Fourth, we saw, in the case of the rifle and the piano, which have both come from the old bow and arrow, that two most unlike things develop from a common source, if they develop on different lines.

Now, these examples and these laws are noted merely to put us in the right attitude to consider a few of the millions of living things, and to observe the grandeur of an evolution which has required millions of years.

CHAPTER II.

ASTRONOMY

MOST people have seen the stars on a clear night, but very few take the trouble to inquire what they are or what we know of them. Wise men studied them thousands of years before Evolution was discovered ; and, though they are so many millions of miles away, yet we know a great deal about their history, nature, forms, and distances. Perhaps in no other department has the brain of man done so much as in astronomy.

The word "astronomy" is from two Greek words, *astron*, a star, and *nemo*, to distribute, and so the word means classing or arranging the stars.

The Latin word for star is *stella*, so when we speak of the system of the stars we call it the stellar system.

As all these bodies move round nearly in a circle, the path through which any body travels is called its orbit, which is from the Latin *orbis*, a circle.

When a small body revolves round a larger it is called its satellite, from the Latin *satelles*, an attendant ; thus the moon is the earth's satellite.

The Latin word for sun is *Sol*, so when we speak of the sun and all the bodies which revolve round him we call it the solar system, which means the sun and all his family.

The universe includes our world and all the other worlds and bodies in space ; it is from the Latin *universum*, the whole; and this Latin word is made

up of two Latin words, *unus*, one, and *verto*, to turn. It is a most suitable word ; it means all the

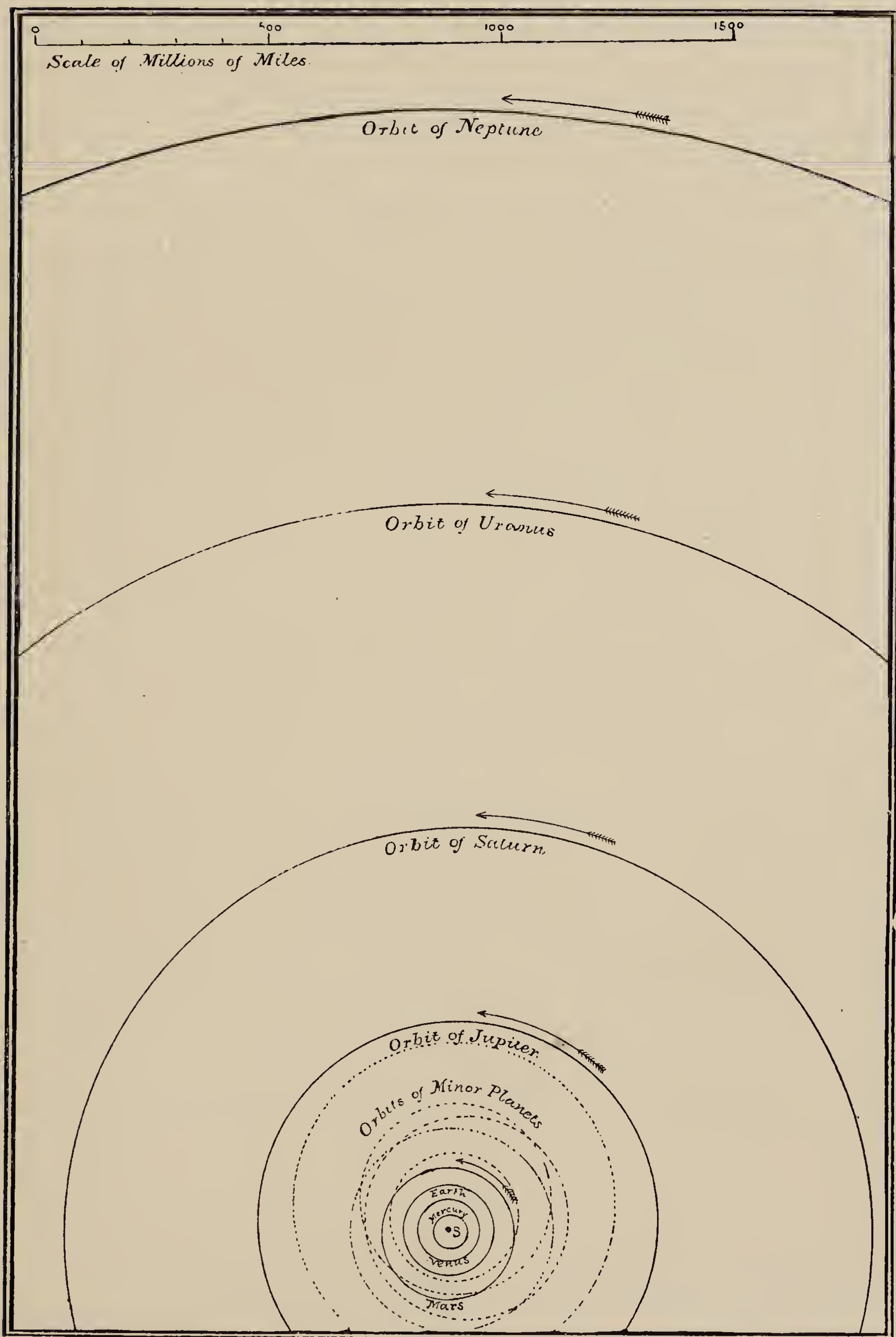


FIG. 16.—The Solar System.

worlds and bodies, and, as they are always going round, we may say they turn—the turning whole.

Now we want to learn how the stars and our world all came into their present state. Were they made just as they are, or do they change often? Are some young and some old? In a word, have they evolved from some other form of matter, and are they still evolving?

Before we can look for laws and their lessons, we must refresh our memories by an outline of the facts of that part of the universe which is best known to us. In other words, we must try and be clear about the solar system. The solar system includes the sun, with those planets, satellites, and smaller bodies which revolve round the sun. The stellar system includes the solar system and all the stars and other bodies which can be seen and discovered by man. Our solar system is only a small speck in the great stellar system.

For the sake of clearness we will begin with the smaller first.

Fig. 16 tells its own story. In the centre of all a bright body represents the sun. The circles show the orbits, or paths, in which the planets revolve. Their sizes are various; the distances incomprehensible. It seems to us a measureless space; it is, in reality, a small compartment in the infinite world of stars.

Note the distance of the earth, which is the third body from the sun. It seems quite near the sun, but it is nearly ninety-three million miles away. If this conveys any meaning, you may try to form some idea of the distance of the farther planets.

There are eight principal planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune. I have given them in the order of their

distance from the sun, Mercury being the nearest and Neptune the farthest.

In early days most of the bright bodies in the heavens were supposed not to move, and they were

Fig. 17.—The Comparative Sizes of the Planets. (After *Flammarion.*)

called fixed stars, though, as a matter of fact, there are no fixed stars, for all the stars are suns, and they all move.

But the sun and moon and a few bright bodies were clearly seen to move, and the Greeks called these moving bodies planets, which means the wanderers. They enumerated seven planets—the sun, moon, Mercury, Venus, Mars, Jupiter, Saturn ; and this is why we have seven days in the week. Some of these days still retain their

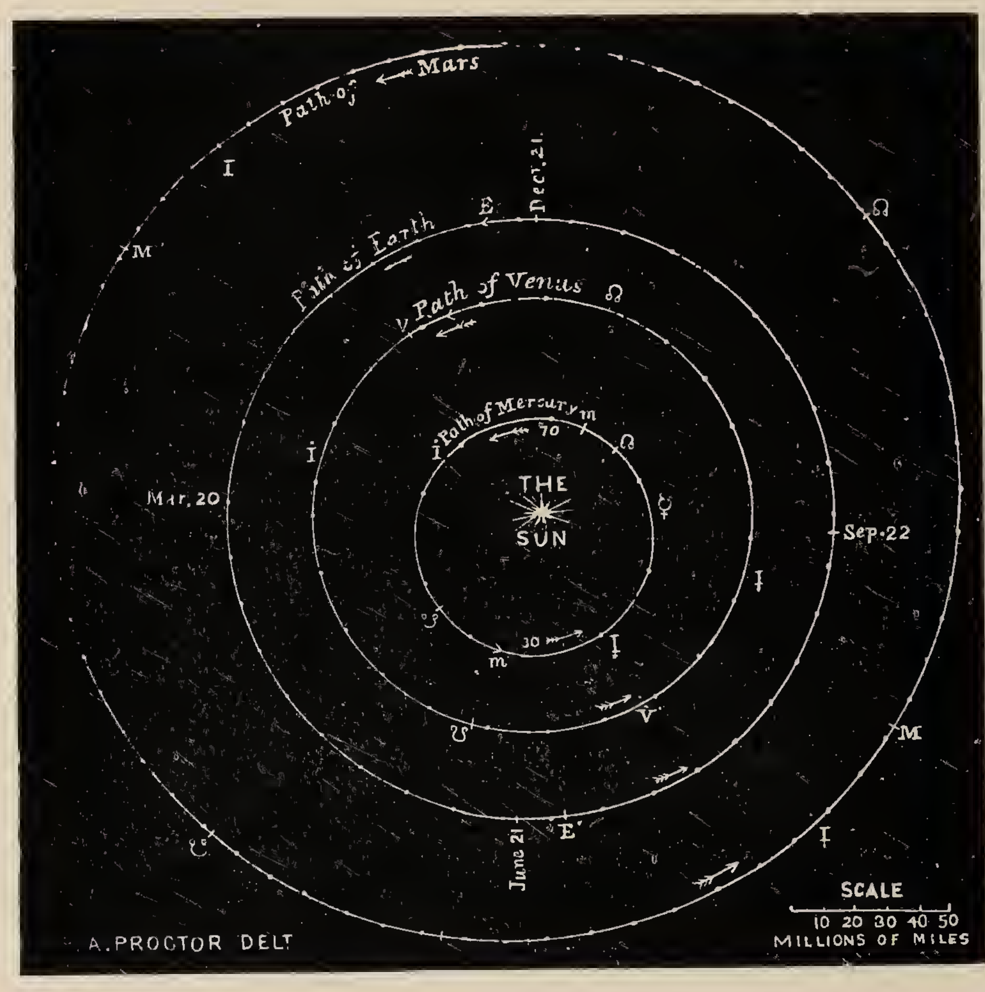


FIG. 18.—The Orbits of the Four Planets nearest the Sun.

planetary names, as Sun's day, Moon's day, Saturn's day. In the end they were treated with great reverence, and included in various religious systems.

But now we do not regard the sun and moon as planets, and Uranus and Neptune have been discovered since ; these, with the

other true planets and our earth, make up the eight planets.

You should note the smallness of the earth (Fig. 17) when compared with the larger planets, which we shall describe more fully. We have said that these planets are not all the same distance from the

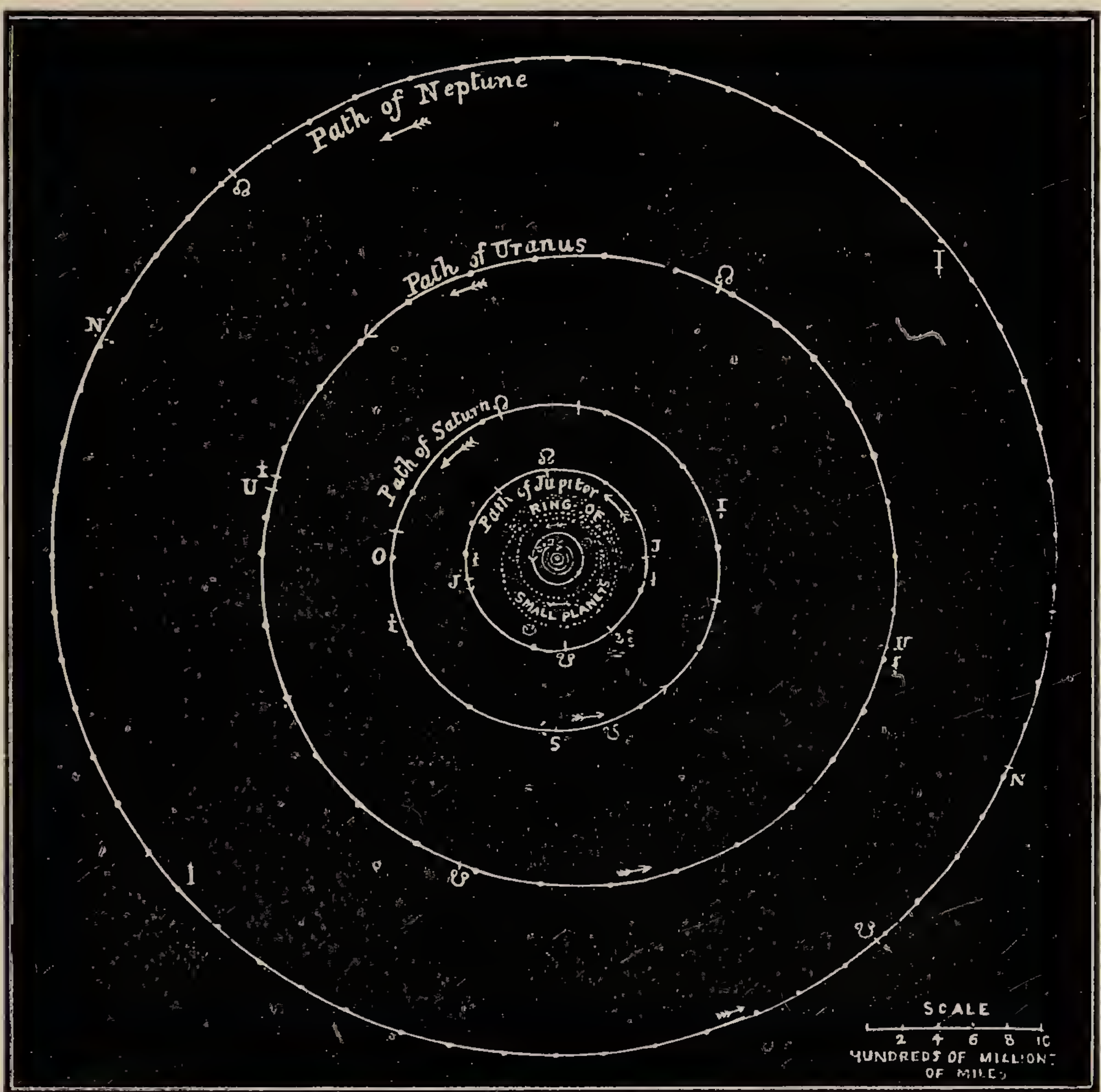


FIG. 19.—The Orbits of the Four Planets farthest from the Sun.

sun. These distances have been carefully calculated; but, as mere figures convey so little in the gigantic measurements of astronomy, we must show the facts by other means. The path in which a planet moves round the sun is called its "orbit," and Fig. 18 gives a correct idea of the distances.

You notice the bright, small body almost in the centre of the smallest circle: this represents the sun. The smallest circle is the path of *Mercury;* the next the path of *Venus;* the third circle the path of the *earth;* the greatest the path of *Mars.*

Between Mars and Jupiter there is a wide gap, in which we should naturally look for another planet. In this gap, up to January, 1902, there had already been discovered 500 little bodies, called "asteroids," which probably represent a single planet, somehow "spoiled in the making," so to speak, or subsequently burst into fragments—(Young, 312).

If you can see the small dot in the centre of Fig. 19, this represents the sun; the fourth *small* circle represents Mars, as in Fig. 18; next is a ring of dots, these represent the asteroids; next is a distinct circle, the path of *Jupiter;* the next is the path of *Saturn;* the largest circle but one, the path of *Uranus;* and the outermost circle, the path of *Neptune.*

Nothing is more difficult than to realise these vast distances. As we have seen, the earth appears comparatively quite near the sun, and yet it is nearly ninety-three million miles off. Various attempts have been made to bring this distance home to us. "A cannon shot seldom exceeds 2,500 ft. per second, yet such a shot would require over six years to reach the sun, travelling without change of speed. A train running at sixty miles an hour, without a stop, would require 175 years to get there, and if you paid a penny a mile the fare one way would be £387,500. A bicyclist who could travel 100 miles a day, without a stop or puncture, would be nearly 2,550 years doing the journey. Light makes the journey in less than eight and a half minutes."

Now, if you begin to see what the distance from the earth to the sun means, remember that the distance from Neptune to the sun is thirty times greater!

It is not necessary to go into detail and show all the known planets. We know the planets of our own solar system only. We can remember that they are all, more or less, *dark* bodies, borrowing their light from the sun; that they all rotate on

FIG. 20.—The Planet Jupiter. (After *Flammarion.*)

their own axes; that they revolve round the sun, and that they have smaller bodies, called satellites, which also rotate on their axes and revolve around the planets.

Jupiter is the giant among the planets (Fig. 20). Its diameter is 88,000 miles, a little over eleven times that of the earth. Its surface is 122 times

that of the earth, and its distance from the sun is 483 million miles.

You observe in this beautiful drawing that the planet is crossed by numerous lines parallel to the planet's equator. These lines are the famous belts of Jupiter. The planet has an extensive atmosphere. "The low density of the planet makes it very doubtful whether there is anything solid about it anywhere—whether it is anything more than a ball of fluid overlaid by cloud and vapour"—(Young, p. 386).

It probably has a high temperature, and it has been called a semi-sun. It receives very little light and heat from the sun, and therefore must supply some of its own heat by a process of condensation. It is one of the planets not yet fit for life of any kind.

Jupiter has seven satellites or moons, which at recurring intervals suffer eclipse.

As Jupiter is the giant planet, Saturn (Fig. 21) may be called the show planet, for this great globe is unique among the heavenly bodies, attended by eight or perhaps nine moons, and surrounded by a system of so-called rings such as has been found nowhere else in the universe. Its mean distance from the sun is 886 million miles, and its greatest distance from the earth is over 1,000 million miles. Its physical condition and constitution are very like those of Jupiter, though still farther from solidity. Like Jupiter, it is not yet fit for any form of life. The most remarkable peculiarity is the system of rings. Galilei discovered them, but the problem of their existence remained unsolved for nearly fifty years, till Huyghens explained the mystery in 1655. Twenty years later it was discovered that the ring was double, with a dark line

of separation between the two; and in 1850, both in America and in England, a third ring was discovered. The brightest ring is about 17,000 miles broad. "It is now universally admitted that these rings are not continuous sheets, either solid or liquid, but a flock or swarm of separate particles, little 'moonlets,' each pursuing its own independent circular orbit around the planet, though all moving nearly in the same plane"—(Young, p. 397).

FIG. 21.—The Planet Saturn. (After *Flammarion.*)

This is known as the meteoric theory of Saturn's rings.

For our purpose we need not go into the details of the rest of the eight planets.

Uranus is 1,782 million miles from the sun. It has four moons.

We must refer to Neptune, because its discovery is the greatest triumph of mathematical astronomy since the time of Newton. It was found that Uranus did not move in the orbit which, according

to all calculations, it ought to have taken. Therefore the mathematicians concluded there must be some other planet which drew Uranus away from its proper path. So accurately were the calculations made that they told the astronomers where to look for the new planet. There Neptune was discovered on the night of September 23rd, 1846, in the Observatory at Berlin. Leverrier, a Frenchman, and Adams, an Englishman, both separately made this discovery by mathematics. Neptune is 2,800 million miles from the sun. This is its mean distance, and is quite incomprehensible to us. It has one moon. So far as known, Neptune is the outermost of the planets of our solar system.

Before leaving the solar system as a whole, it may help us if we quote the illustration of its dimensions given by Sir John Herschel. He says: "Choose one well-levelled field. On it place a globe 2 ft. in diameter. This will represent the sun. Mercury will be represented by a grain of mustard seed on the circumference of a circle 164 ft. in diameter for its orbit; Venus, by a pea, on a circle 284 ft. in diameter; the earth, also by a pea, on a circle of 430 ft.; Mars, by a rather large pin's head, on a circle 654 ft.; the asteroids, by grains of sand, on orbits having a diameter of 1,000 to 1,200 ft.; Jupiter, by a moderate-sized orange, on a circle nearly half a mile across; Saturn, by a small orange, on a circle four-fifths of a mile; Uranus, by a full-sized cherry, upon the circumference of a circle more than a mile in diameter; and, finally, Neptune, by a good-sized plum, on a circle two and a half miles in diameter." Professor Young says: "We may add that on this scale the nearest star would be on the opposite side of the earth, 8,000 miles away"—(p. 344).

At the bottom of Fig. 22 are two separate craters of the moon.

I give this to show how intimately the surface of the moon is known, and also because the moon is a dead orb, its volcanoes extinct, its air exhausted. It is one of the numerous heavenly bodies which

FIG. 22.—The Full Moon. (After *Flammarion.*)

has passed through its youth, suffered the decay of age, and finally died. In these respects it differs entirely from Jupiter and Neptune, which are still so young that they are not yet solid. Strange thoughts arise when one contemplates the solar system as a family, in which some are young,

CELESTIAL PLANISPHERE.—I.

Containing the principal stars visible to the naked eye.

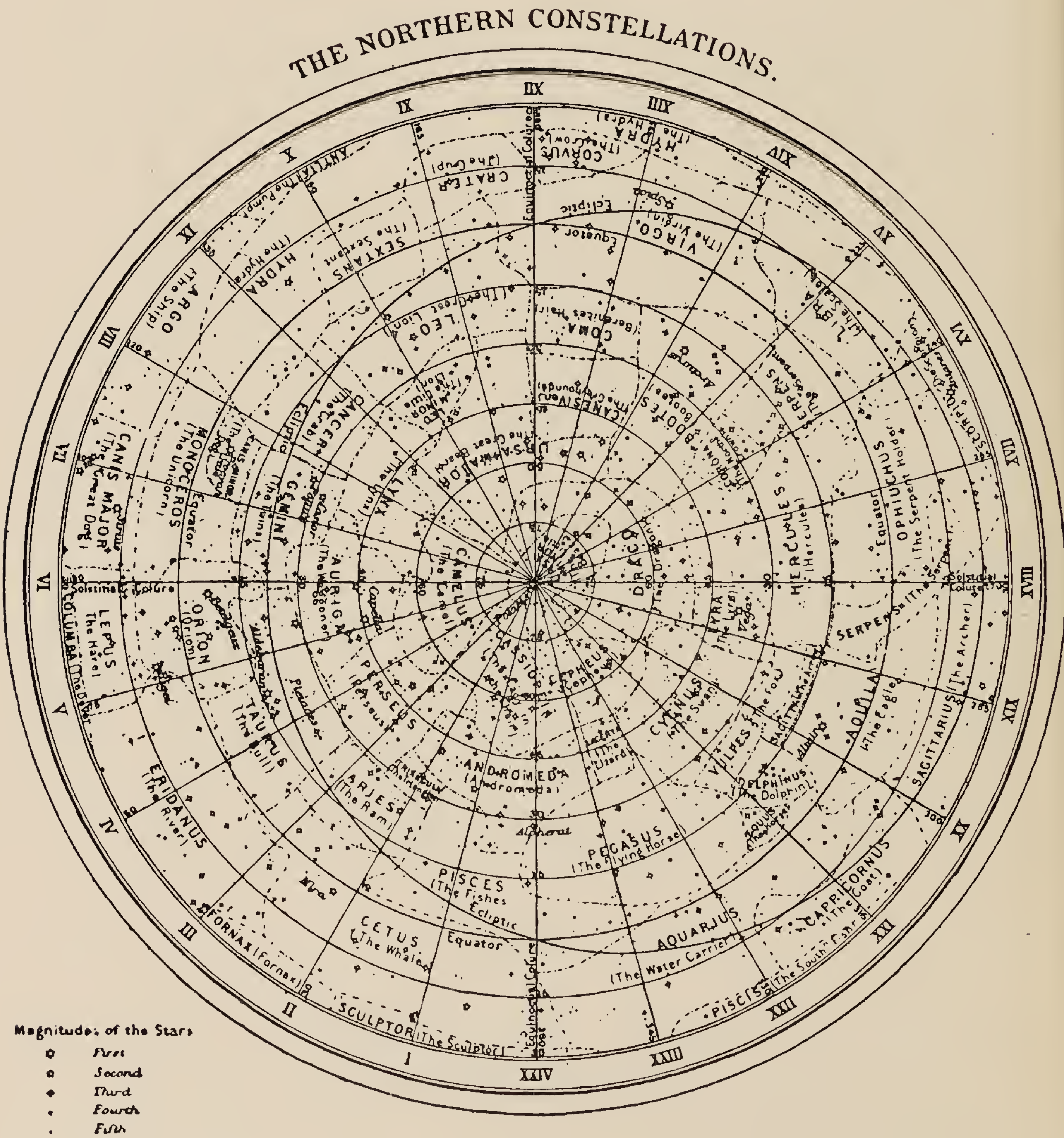


FIG. 23.—The Northern Hemisphere of Stars. (After *Flammarion*).

CELESTIAL PLANISPHERE.—II.

Containing the principal stars visible to the naked eye.

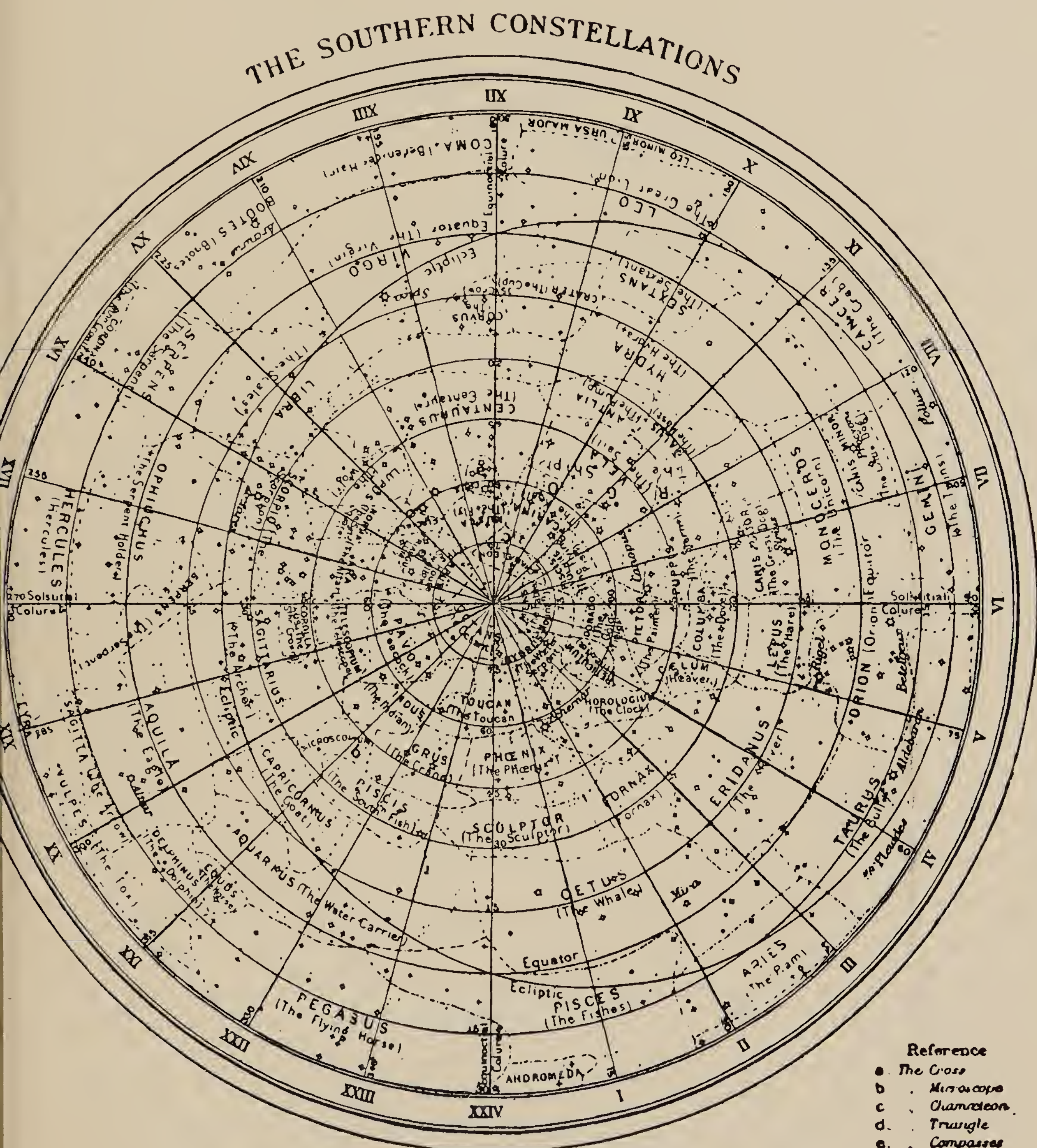


FIG. 24.—The Southern Hemisphere of Stars. (After *Flammarion*).

some in the prime of middle life, some aged and worn out. We must soon inquire into the meaning of this.

"Our solar system is an island in space, surrounded by an immense void inhabited only by meteors and comets." Beyond this girdling void the nearest known star is at a distance quite inexpressible by earthly numbers. In order to indicate how far it is from us, we have to express the distance in astronomical units. An astronomical unit is the distance of the sun from the earth—nearly ninety-three million miles. Now, the nearest star is 275,000 astronomical units away from us. The nearest star is double, and is called Alpha Centauri.

Note on the two figures, 23 and 24, you have only the stars visible to the naked eye.

The number of stars which can be seen by an average eye is between six and seven thousand, but those to be seen by a good telescope probably reach over 100 million—(Young, p. 478). When we remember that all these stars are suns, just as our sun is a star, and that probably each of these stars has its own system of planets, though they are too small to be seen at such an immense distance, we begin to feel dazed by their infinite numbers and their infinite distances.

We turn, therefore, with enthusiastic curiosity to inquire how this system of bewildering marvels has arisen. Is there any explanation? Does a system of such wondrous grandeur bear any marks of growth or of decay, of its origin or of its end? Were they made once for all as they are now, or have they been evolved by the same laws which have produced the protozoa of the ocean and the geniuses among mankind?

There is an explanation which has been generally accepted by men of science. It is called *the nebular hypothesis*. Let us see what it says. Any explanation which can gather into one whole the planets and their moons, the sun itself, the comets, the meteors, the millions of blazing suns in infinite space, and the vast nebulæ lying like stains of

FIG. 25.—Kant. Born 1724, died 1804.

light on the midnight sky, is an explanation which commands the reverent admiration of men.

With such recommendation is the nebular hypothesis presented to us.

Its origin is scarcely less wonderful.

It was discovered by three men of quite different characters, methods, and nationalities. These men were Kant, Laplace, William Herschel.

Kant's father was a saddler, the son of a Scotsman. He spent his life as professor at the University of Königsburg. In 1755 he first announced "that the earth, the sun, the planets, and all the bodies now forming the solar system, did really originate from a vast contracting nebula"—(Ball, p. 6). Afterwards Kant left scientific speculations, and became immortal as a philosopher of the most metaphysical type.

Laplace was the son of a farmer, but got help

Fig. 26.—Laplace. Born 1749, died 1827.

and letters of introduction to the great D'Alembert in Paris, where afterwards he was Professor of Mathematics. In 1796 he brought out the great nebular theory, based strictly on mathematics. The hypothesis has become associated with his name, because he went into greater details and gave mathematical demonstrations.

Herschel was the son of a Hanoverian musician, and at fourteen entered the band of the Guards. He came to England at the age of nineteen, and

soon was settled at Bath as organist and music teacher. His hobby was making telescopes, so that he might spend his nights watching the heavens. When he was forty-two he discovered the planet Uranus, which at once made him famous. He gave up music, he constructed better telescopes, he settled at Slough for forty years, and, by the aid of his illustrious sister Caroline, he studied the heavens in order to solve some of the

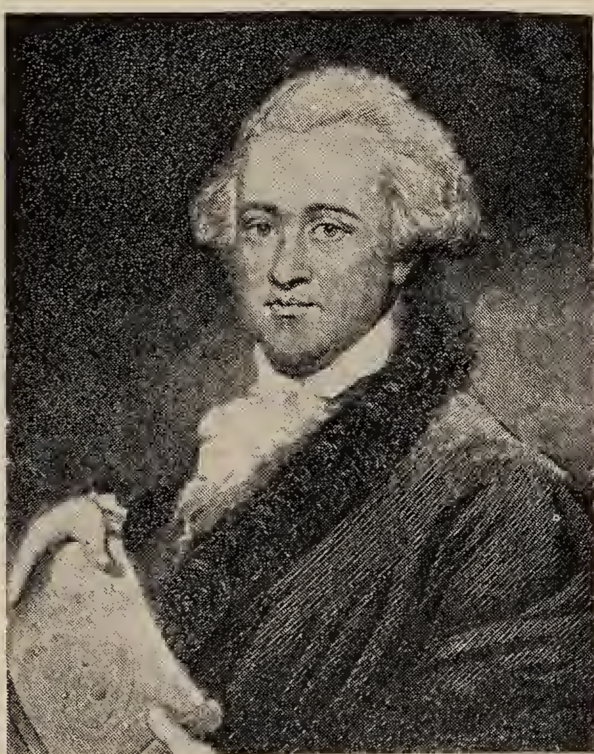


FIG. 27.—The first William Herschel. Born at Hanover 1738, died in England 1822.

mysteries of the universe, while he lived on a Royal pension of £200 a year!

By his constant labours he perceived that between a nebula, "which was merely a diffused stain of light on the sky, and an object which was hardly distinguishable from a star with a slight haze round it, *every intermediate grade* could be found. In this way he was led to the splendid discovery which announced the gradual transformation of nebulæ into stars."

Whatever views we may hold of the nebular hypothesis, all must agree that it has a most marvellous history. Kant by pure abstract speculation, Laplace by the wondrous calculations of mathematics, William Herschel by accurate study of the heavens, independently came to the same conclusion, that the whole universe had evolved, and that every "*body*" in the solar system and the stellar universe had condensed into its present form from an infinite gas. This is the great nebular hypothesis. *Nebula* is the Latin for mist, vapour, cloud. But we must not think of the earliest condition of the nebula, from which all stars may have come, as like mist or cloud such as we know. The original nebula was much lighter than any gas with which we are familiar.

Hypothesis is from two Greek words—*hypo*, under, and *tithemi*, to place. It means a scientific supposition to explain observed facts. That all the planets and suns were formed from some primal mist is the explanation offered by the nebular hypothesis.

As discovered by the three illustrious men we have named, the hypothesis naturally differed in some points of detail with regard to the way in which the worlds had been formed; but upon the greatest point they all agreed. Kant first gave the theory to the world in 1755—*i.e.*, just about 150 years ago. During this period thousands of men have devoted their lives to astronomy, thousands of discoveries have been made; and we have now to inquire whether, after 150 years of remarkable scientific activity, the evolution of the millions of worlds is proved or discredited. As we can deal with only a few typical facts, many details must be omitted.

We will glance at the history of the earth and the sun.

Note, the earth's orbit in Fig. 28 is not a circle, but an ellipse. Its different positions, as it goes

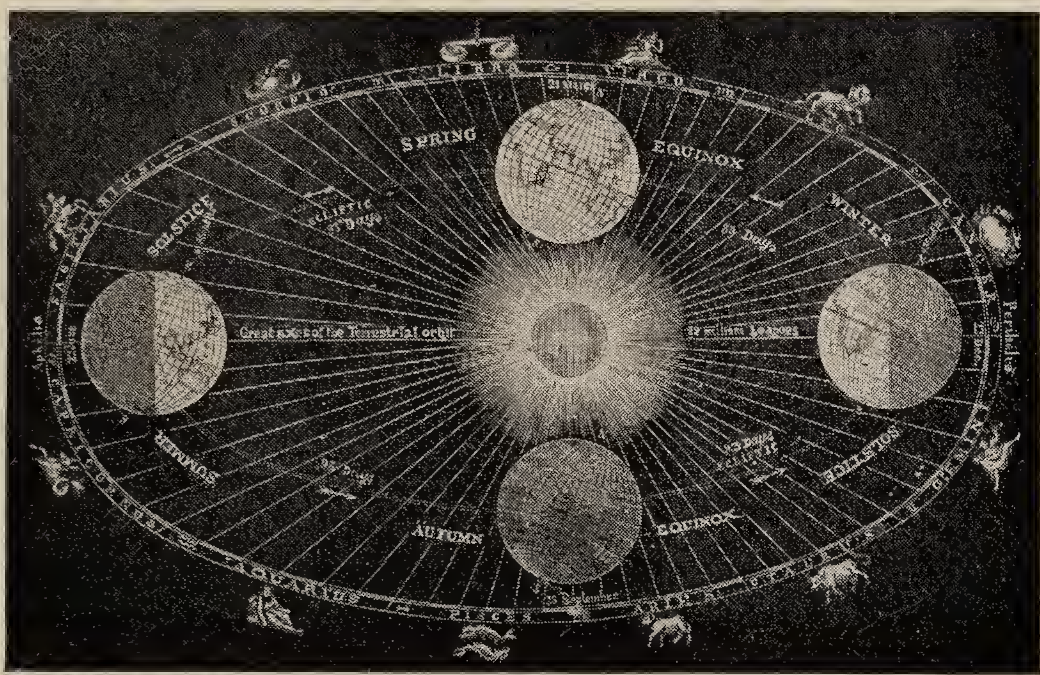


FIG. 28.—The Earth's Orbit or Path round the Sun. (After *Flammarion.*)

round the sun, are the causes of the seasons of the year.

The different inclinations of the earth, as shown in Fig. 29, also have a great deal to do with

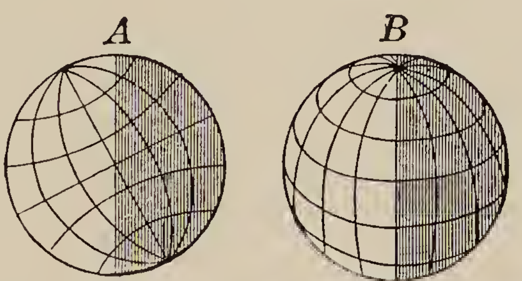


FIG. 29.—Different Inclination of the Earth to the Sun.

causing the different seasons of the year. *A* is the position at solstice. *B* is the position at equinox.

We must not suppose that there is a *material* axis upon which the earth turns. The earth swings

in space, but it has a rotatory motion, by which it turns round, as if upon an axis, every twenty-four hours. The needle represents the axis (Fig. 30).

As we have seen, the smaller body goes round the larger body once a year. This is an enormous journey. We ought to try to grasp the extraordinary motions of our little earth : it rotates on its own axis more than 1,000 miles an hour ; it goes round the sun more than 1,000 miles a minute ; by the sun's attraction it, as well as all the other solar bodies, is carried through space at the rate of

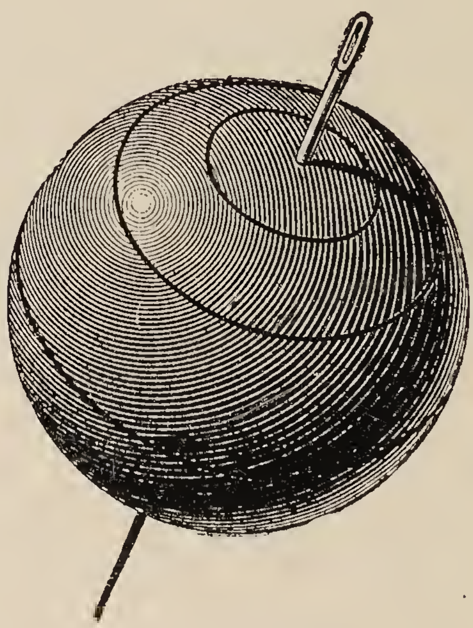


FIG. 30.—The Earth turning upon its Axis. (After *Flammarion.*)

more than 40,000 miles an hour. Perhaps not one of these motions is conceivable by us, and yet, besides these three great motions, there are eight other ascertained motions, so that we need not wonder that the earth never travels twice in the same place.

The moon is the earth's satellite, and the birth of the moon is one of the great epochs in the history of our earth. We are not able yet to trace the history of the earth to that point when it left

the sun, but we can retrace a good deal of the history of that wonderful event when the earth cast off the moon. Professor G. H. Darwin, son of the most illustrious Charles Darwin, has worked out the details of this great event with amazing toil.

Perhaps the most striking fact for us in this history of the birth of the moon is that the earth at

FIG. 31.—The Relative Sizes of the Earth and the Sun. (After *Flammarion.*)

that time must have been in a somewhat plastic or fluid state, otherwise the enormous speed of its motions would not have been able to throw off the moon.

Professor Darwin has shown that not only does the moon cause tides on the earth, but that the earth would cause tides on the moon—not ocean-

tides, of course, for there is no water in the moon, nor *now* bodily tides in the solid moon. But the moon was not solid then, or it would not have left the earth ; and when it was first thrown off it must have been very near the earth, though, owing to the tides caused by the satellite on its planet, and by the planet on its satellite, great changes are produced in their relative motion.

FIG. 32.—The Relative Sizes of the Earth and the Moon. (After *Flammarion.*)

By this powerful attraction each tries to bring the rotation of the other into harmony with the period of revolution of the pair round each other. Owing to this law, very great changes will occur in the earth's movements. Professor Turner points out : " Something like fifty-seven million years ago

there was only one day in the month—*i.e.*, the moon was running round the earth as quickly as the latter rotated on its axis."

According to Laplace, "The whole solar system has been generated from a single nebula, the greater part of which now forms the sun. As this nebula contracted from its original diffused form, rotating faster and faster, it threw *off rings*, which broke up and formed the planets. In the same way these generated their satellites." This wonderful generalisation *appears to be quite true* with regard to some of the systems, as Jupiter with its seven moons and Saturn with its eight or nine ; but the origin of our moon is not explained in quite the same way. I note this chiefly to bring out the fact that the nebular hypothesis may be true without supposing that every planet has acted in exactly the same manner. In the case of the earth it seems that a small piece broke off to form the moon—(Ball, p. 254).

We have seen that, in the case of Saturn, the rings are still there in the form of rings. According to Flammarion and Gore, the most distant known planet, Neptune, would be detached from the sun, or the nebula which was to form the sun, at the time when this nebula extended as far as that planet's orbit, to nearly 3,000 million miles out, and when the nebular mass was turning at the slow rate requiring 165 years for each rotation. It takes Saturn 165 years now to travel once round its orbit. The original ring could not remain in the state of a ring unless it had been of exactly the same density and regularity of motion throughout —a thing which never happens. "Successively, Uranus, Saturn, Jupiter, the army of small planets —the asteroids—Mars, would thus be detached or

formed in the interior of this same nebula, till at last it would come to the earth, of which the birth goes back to the epoch when the sun had arrived at the present position of the earth's orbit"—(Flammarion, p. 73).

Venus and Mercury would, according to this theory, be born later. Flammarion says: "The relative density of the planets strengthens this theory. The moon, formed from matter, floating, so to say, on the terrestrial nebula, is very much lighter than the earth. The superior planets, Neptune, Uranus, Saturn, and Jupiter, are much

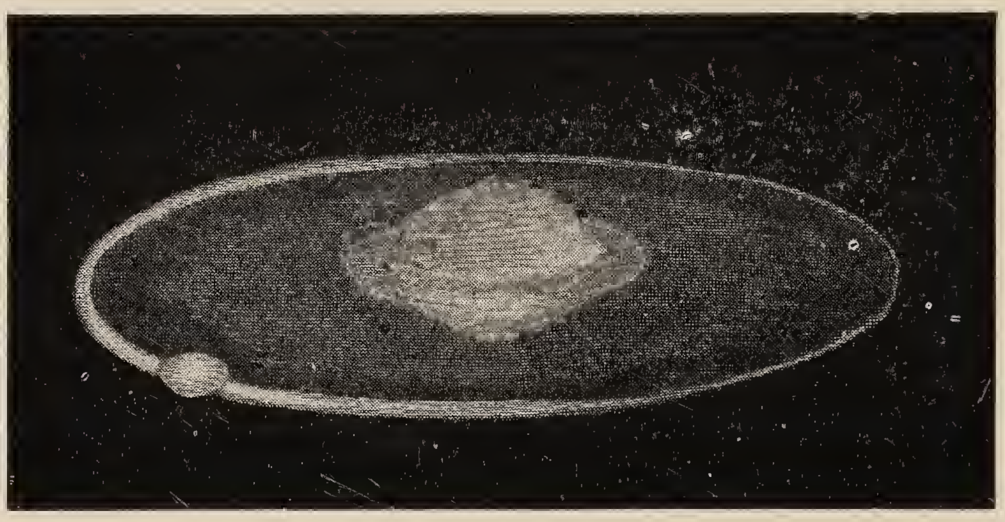


FIG. 33.—Flammarion's representation of the way in which the Earth may have been cast off from the Sun as a ring.

less dense than the inferior planets, Mars, the Earth, Venus, and Mercury. Besides, we find in the chemical composition of the different worlds, and even in that of comets, of shooting stars, and of meteoric stones, the same materials which compose the earth, and which exist also in the gaseous state of the sun"—(p. 74).

If the earth was formed by the slow condensation of a *gaseous ring* detached from the contracting sun, it may have taken place as represented in Fig. 33. You see a large body with a bulging equator, like

the ring of Saturn; the large thin outer ring has become separated from the central body, and it is beginning to condense on one point on the left of this outer ring.

So much for the earth at present. Let us now turn to the history of the sun.

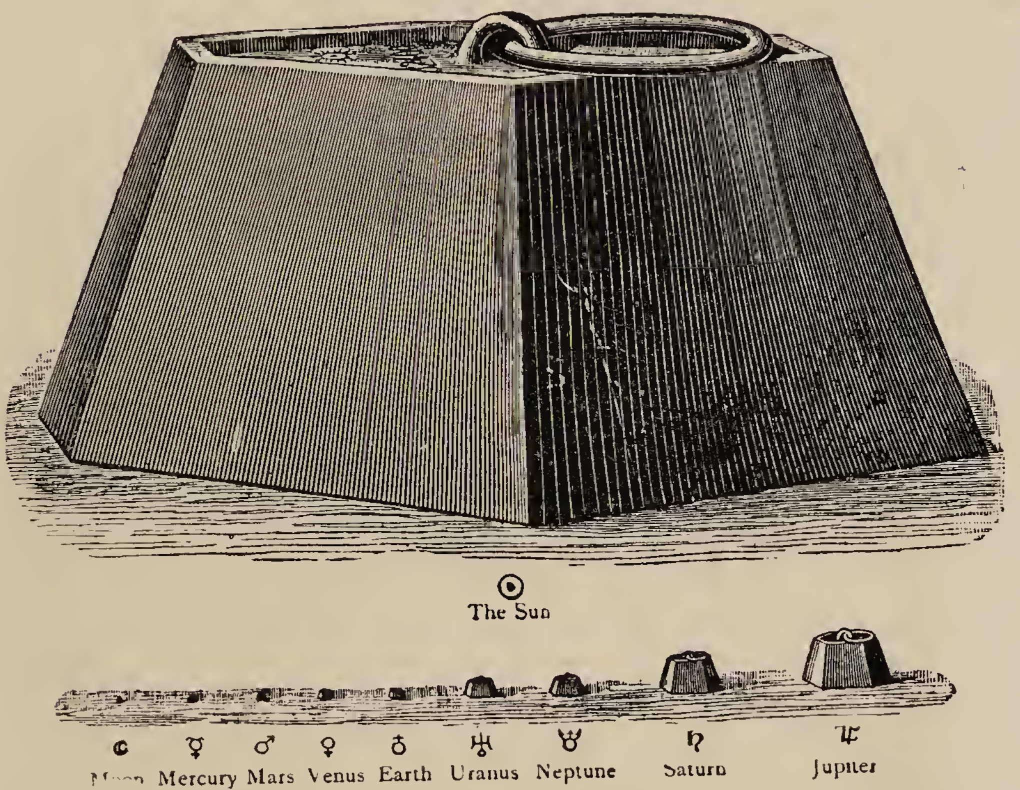


Fig. 34.—Weights representing the masses of the Celestial Bodies. (After *Flammarion.*)

In addition to the sun, the solar system consists of—

- Eight large planets.
- Thousands of small planets (moons and asteroids).
- Meteoric bodies.
- Comets.
- The zodiacal light.

If all the matter in all these bodies could be piled into one mass, it would be the merest fraction of the matter composing the sun (Fig. 34).

We must try to remember that all the matter now forming the solar system once existed as a

huge nebulous mass extending far beyond the orbit of Neptune, and that this mass must have been 200 million times less dense than hydrogen, which is the lightest gas we know.

In Fig. 35 we see the sun with spots, but this conveys no idea of their vast size.

In Fig. 36 there are two spots, one above and one below the equator. These look like two rows

FIG. 35.—The Sun with spots. (After *Flammarion.*)

of spots, because the two spots are being carried round by the rotation of the sun. In fact, they afford us the means of measuring the time which the sun takes to rotate on its axis.

In Fig. 37 is seen one of the largest sun spots. You can form some idea of its size by comparing it with the size of the earth at the top left-hand corner.

It is not yet determined what these spots are or how they are caused, or whether they affect the weather on our little planet or not; but they appear to be connected with magnetic disturbances.

When there is an eclipse of the sun, remarkable flame prominences are seen on its surface, as shown in Fig. 38.

Observe that they are over 124 thousand miles

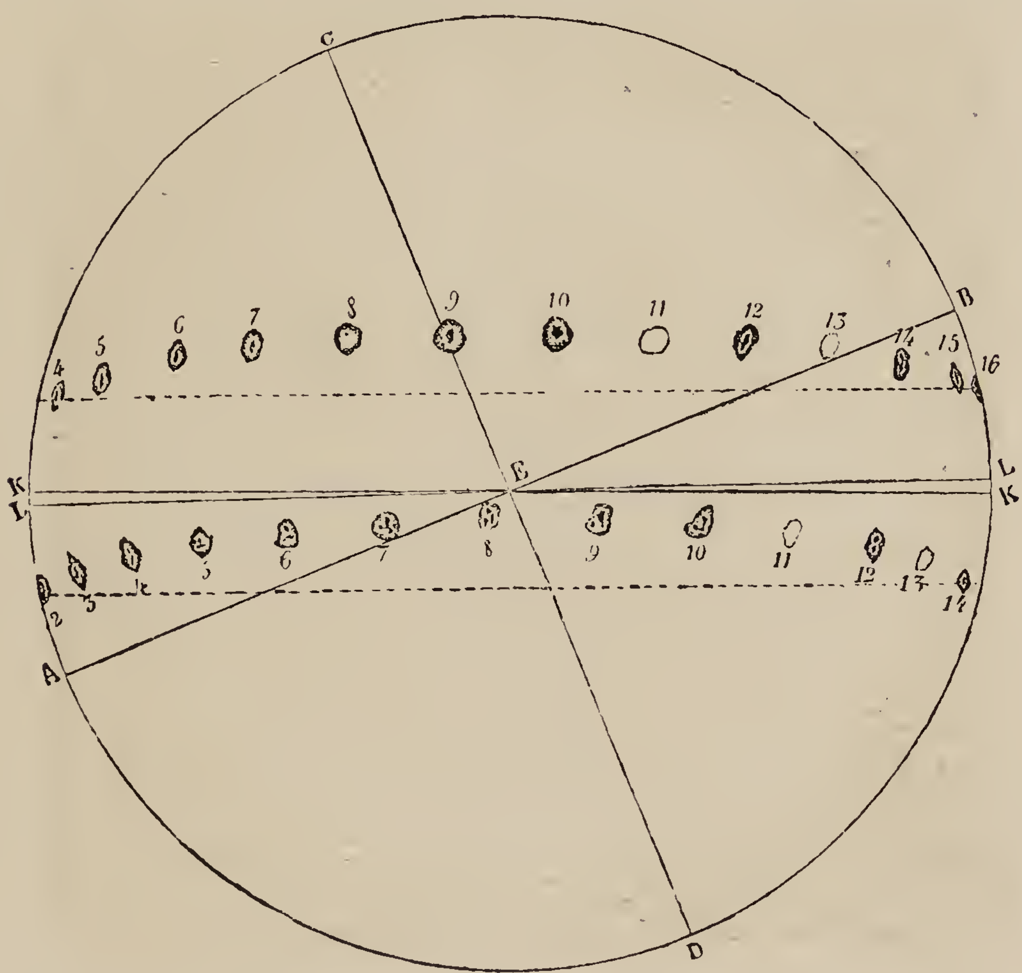


FIG. 36.—Two Sun spots. (After *Flammarion.*)

high. Again, you see our little earth in the top left-hand corner, which may help you to realise the space filled by these flames.

This brings us to the very interesting question of the source of the heat of the sun. Heat is only a form of energy, and energy, like matter, cannot itself be created out of nothing. We have,

therefore, to inquire whence comes the energy which supplies the heat of the sun. Unfortunately, it is not possible for many of us to grasp even partly what is implied by the sun's heat, because we have such a feeble notion of the size of the sun. The sun's diameter is 866,500 miles—*i.e.*, 109½ times the diameter of our earth; its area is 12,000 times

FIG. 37.—One of the largest Sun spots. (After *Flammarion.*)

the surface of the earth; its volume or bulk is 1,300,000 times that of the earth—(Young, p. 197). In fact, if the sun were hollow, and the earth and moon could be placed inside it, the earth could rotate on its axis, and the moon go round her orbit, and yet not occupy half the sun's internal space, as in Fig. 39.

All within the outer circle represents the internal space of the sun; little dots represent the earth and moon in proportion to their sizes; the inner circle represents the moon's path round the earth. Note how small these dots are compared with a sun-spot,

FIG. 38.—Flames observed at Rome. (After *Flammarion.*)

or with the flame prominences on the right hand of the surface.

Now, with this representation of the size of the sun, let us try to form some idea of the heat of the sun.

When we speak of the sun as a fire we are in danger of thinking that its heat is derived from the combustion of some material, as an ordinary fire burns up coal and wood. Such an idea is entirely wrong.

If a body the weight of the sun were a solid mass of coal, and there were enough oxygen to burn it,

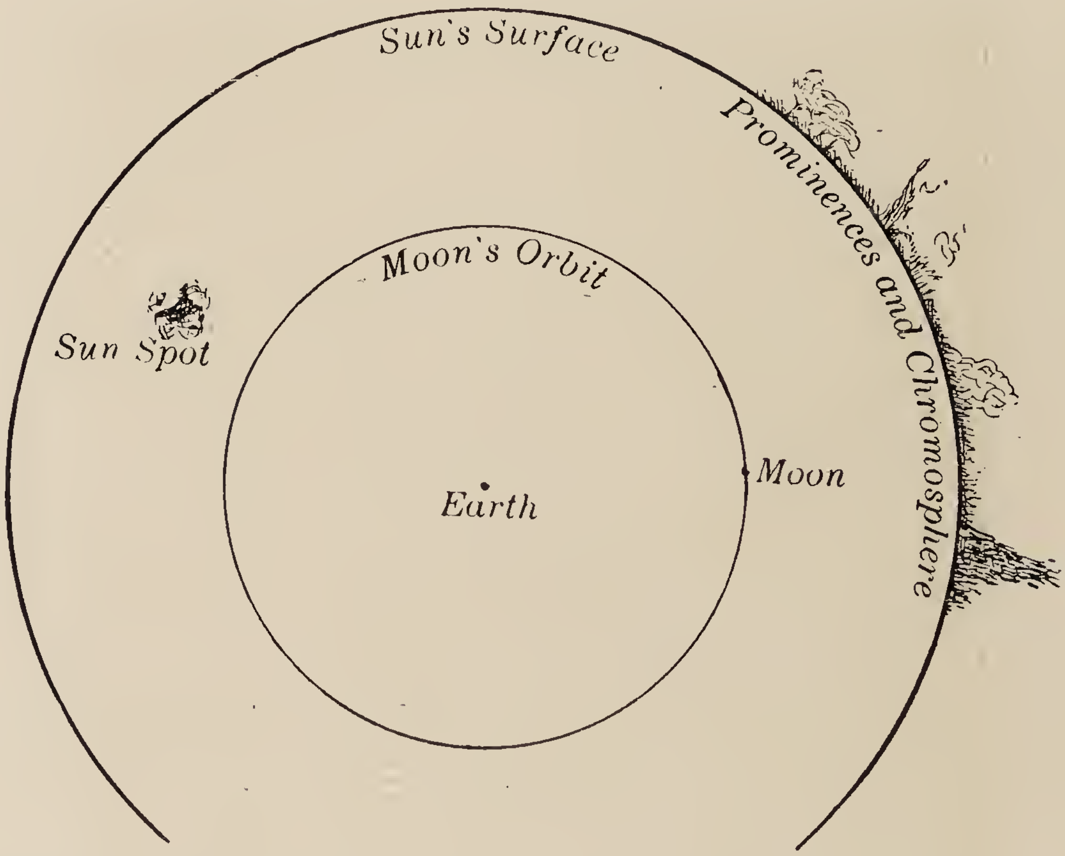


FIG. 39.—Dimensions of the Sun compared with the Moon's Orbit. (After *Young*.)

we know it would only supply the sun's radiation, at its present rate, for 2,800 years—(Ball, p. 111). But the sun has been giving out its enormous heat for millions of years, and it is calculated that it can continue to do this for another ten million years. So we must *not* think of combustion as the source of its heat.

If the nebular hypothesis is true, and if the sun

has contracted from a vast, primeval nebula, which used to fill the whole space of the present solar system, then we know that this *contraction* would cause *enormous heat*. Young says (in 1902) that "the only rational explanation of the facts thus far presented is that which makes the sun a huge, cloud-mantled ball of elastic substance slowly shrinking

FIG. 40.—An ideal representation of the shrinking Sun. (After *Sir Robert Ball.*)

under its own central gravity, and thus converting into the *kinetic* energy of heat the potential energy of its particles as they gradually settle towards its centre"—(p. 570).

We know the sun is shrinking every year.

The small circle in the centre of Fig. 40 represents

the present sun; the next circle represents the size of the sun in very early times; the third circle represents the size in times very much earlier still; the outer circle shows the present orbit of the earth. The sun is still shrinking so rapidly that its diameter is a mile shorter every eleven years—(Ball, p. 114). This may sound small, but in a million years it amounts to nearly 100,000 miles. The wise Hammurabi sat on the throne of Babylon 2,220 years B.C., and since his time the diameter of the sun has diminished over 373 miles, which is nearly equal to the distance from London to Edinburgh. This shrinkage is enough to account for all the heat of the sun, though it is true that *some* of the *heat* may be accounted for by the *meteors* that fall into the sun every year. Thousands of tons of these bodies are attracted into the sun annually.

This contraction cannot go on for ever, and, if this were the chief source of its heat, in the course of some ten million years probably its temperature would fall and its function as a sun come to an end.

The source of the sun's heat has always been a great problem, for, according to calculations from contraction, the age of the solar system would only be about twenty million years; but this is not enough for the geologist, who requires from fifty to a thousand million years for the history of the earth alone.

Professor G. H. Darwin, in his address to the British Association on August 30th, 1905, refers to his wonderful calculations on the tidal influences between the earth and its moon. He says: "It does not seem unreasonable to suppose that 500 to 1,000 million years may have elapsed since the birth of the moon" from the earth.

"This demands that the age of the sun must be

vastly longer than physicists have hitherto allowed. For forty years there has been this difficulty between the demands of geologists and the conclusions of the physicists. But recent discoveries in radium show that contraction of the sun and falling meteors are not the only sources of the sun's heat. Radium is, perhaps, a million times more powerful than dynamite. Twenty-two ounces of radium would furnish enough energy to tow a ship of 12,000 tons a distance of 6,000 sea miles."

FIG. 41.—A Comet.

The earth has radio-active forces, and "it is almost certain that the sun is radio-active also"—(G. H. Darwin).

Sir Robert Ball said (October 3rd, 1905): "If there were as much radium in the sun—*i.e.*, presumably as much radium in one mass—as would be equal to one three-hundred-thousandth part of its size, it would keep the sun going for 1,000 million years, which would perhaps satisfy the geologist."

Thus disappears the huge difficulty with regard to the *time* required for evolution.

Before we turn to consider the great universe of stars, of which our solar system is a mere speck, we ought to say a word on comets and meteors.

The origin of comets is not yet absolutely settled, but many points about their motion seem to indicate that they are visitors from stellar space to our solar system. If this turns out to be true, they are of intense interest to us, being the only messengers

FIG. 42.—A shower of Meteors.

from those infinite regions of the universe. As such they certainly would help to support the nebular theory.

On the other hand, if they are from far distant, outlying clouds of nebulous matter which accompany our solar system in its journey through space, they also support the nebular theory.

The physical constitution and behaviour of comets are perplexing. Comets are subject to the attraction of gravitation, and yet they are acted upon by

powerful *repulsive* forces emanating from the sun. They shine partly by reflected light, and yet they are certainly self-luminous. They are the bulkiest bodies known, except the nebulæ, in some cases thousands of times larger than the sun or stars; but in mass so light are they that they are "airy nothings"—(Young, p. 435). The head of a comet is often ten to fifteen thousand miles across; the tail is frequently fifty million miles long. There are probably many thousands of comets.

Of meteors or shooting stars (Fig. 42) there are untold millions. Dr. See estimates that at least 100 million enter our atmosphere *daily*.

Meteors are small bodies, and, as they are consumed in the air, all that we can hope to get of their materials is their ashes—(Young, p. 465). But the effect of such ashes is practically insensible, though they add continually to the mass of the earth. If we assume that 20,000,000 meteors fall each day, and that each weighs one-sixtieth of a pound, the total amount would be 50,000 tons a year. Such a weight sounds startling at first, but, even at this rate, for them to deposit a one-inch layer on the earth's surface would require about 800,000,000 years. We are in no danger of being earthed up by meteoric dust!

Yet these small bodies, constantly falling, diminish the length of the year in three ways: (1) By acting as a resisting medium; (2) by increasing the mass of the earth and sun, and so increasing the attraction between them; (3) by increasing the size of the earth, thus slackening its rotation, lengthening the day, and making fewer days in the year. So marvellously delicate and so miraculously complex are the operations of this infinite universe! Not least wonderful is the fact that there is "a real and

close connection" between the orbits of meteor swarms and the orbits of the comets which are their attendants.

Their origin is not determined, but it seems that they are from planets rather than from stars, and Young says they may be "minute outriders of the asteroid family."

When the meteors are sufficiently large to resist the action of our atmosphere, and actually complete their fall to the earth, they are called meteorites.

Fig. 43 shows the celebrated meteorite which fell at

FIG. 43.—A Meteorite.

Gross Divina, Hungary, in 1837, and weighs about twenty-four pounds. The total number gathered up from the year 1800 to 1902 is about 275. The largest single mass weighed 647 pounds. In eight cases they have been found to be almost purely iron. The finest collection of these stones in the world is at Vienna, but our British Museum, Paris, and Yale, all have good collections.

Our interest lies in their message, for they are

visitors from far distant regions, and the earth is not their mother. Their message is that Nature is one. Twenty-seven of the chemical elements,

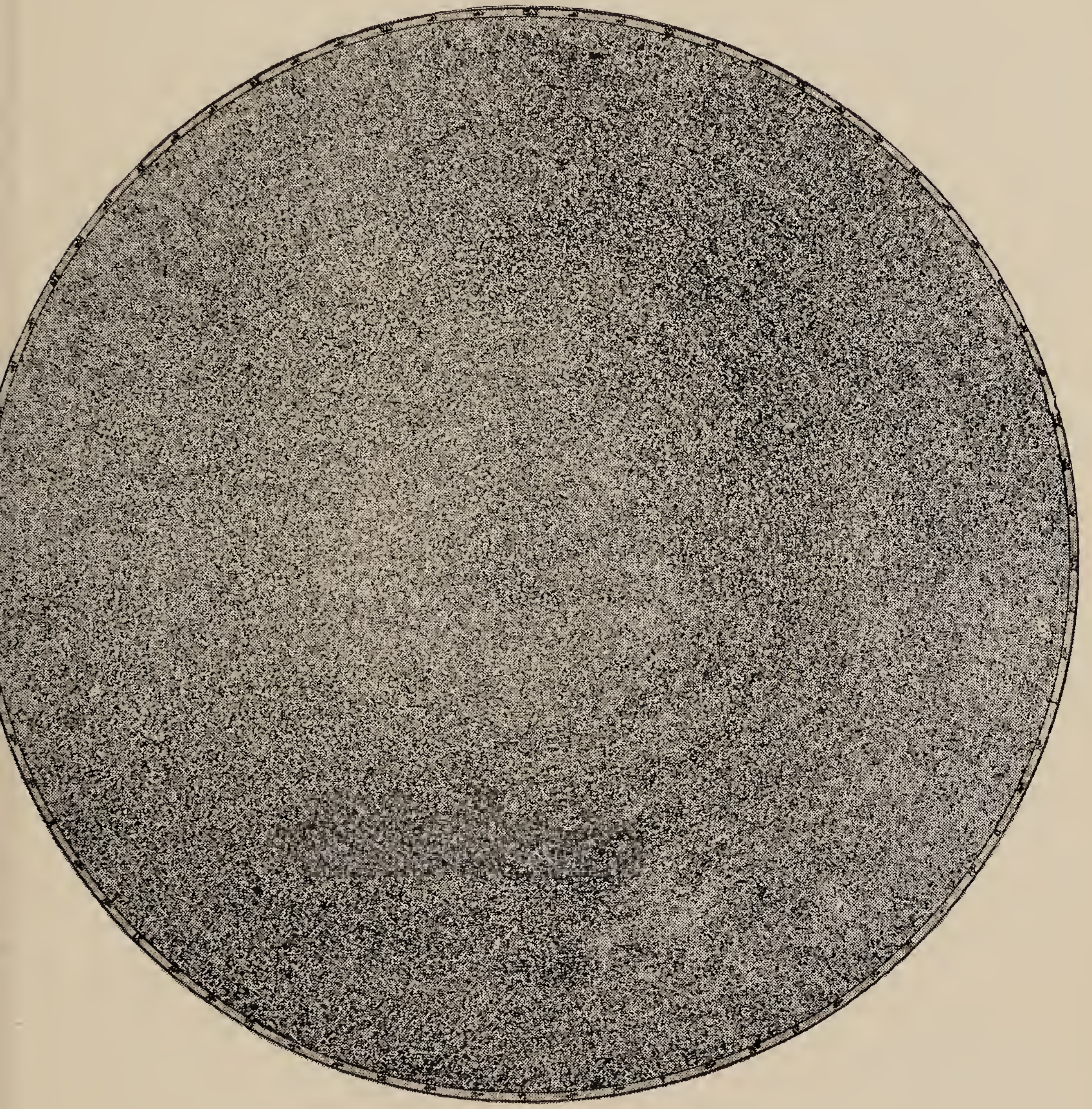


FIG. 44.—The distribution of 324,198 Stars which have been catalogued for the Northern hemisphere.

including those novelties, argon and helium, have been found in meteorites, but not a single *new element.* Many of the *minerals* of these meteorites

present a great resemblance to terrestrial minerals of volcanic origin, but there are also many which are peculiar and not found on the earth. Such is the power of *environment;* no new elements, but new combinations !

When we turn to the universe of stars words fail to convey any idea of their grandeur. We are dazed alike by their infinite numbers and their infinite distances. We can look at but a few of

FIG. 45.—The Star Cluster in Centaurus. (After *Flammarion.*)

these marvels. Only few minds can realise that every faint spot on Fig. 44 represents a star—*i.e.*, a sun which probably has planets, not shown here, revolving round it.

Undoubtedly two of the most amazing spectacles in the whole heavens are Figs. 45 and 46.

Star clusters are numerous in the sky, and contain groups of stars from a hundred to many thousands ; we have hurried through them by giving two

examples only, for we must hasten to our last point —the nebulæ.

It used to be urged against the nebular theory that no one knew that any nebular matter could be found in the universe. This was a strong objection, and when the larger telescopes were invented, and many nebulæ were resolved into star-clusters, the

FIG. 46.—The Cluster in Hercules (13 Messier). (After *Flammarion.*)

objection acquired still greater force and seemed almost unanswerable. But about the year 1860 the astronomer acquired a new instrument. This was the spectroscope. The essential part of this instrument is a prism or a train of prisms. It performs the office of breaking up light, or, to speak more accurately, of dispersing the rays of different wave-length and colour.

If you take a three-sided strip of glass, you can split up sunlight yourself into the colours of the rainbow, the colours of which are only sunlight split up by raindrops. The band of colours produced by the glass prism is called the spectrum. Various lights give various spectra, and, by means of the spectroscope, chemical elements can be

FIG. 47.—A diffused Nebulosity. (N. g. c. 1499; in Perseus.)

identified. The spectroscope has done almost as much for astronomers as the telescope, and among its great achievements is the power to distinguish between star-clusters and nebulæ. There is no longer any doubt which is which. A nebula is composed mainly, if not entirely, of gaseous matter. In the green nebulæ, hydrogen, helium,

and some unknown gases are certainly present, and these gases *emit most of the light* that reaches us from them—(Young, p. 558).

A nebula is that rarified form of matter from which the heavenly bodies have been formed. There are thousands of these nebulæ in many shapes. This nebular matter has been called "the matrix of the stars," and it is remarkable that the

Fig. 48.—An irregular Nebula. (N. g. c. 6992; in Cygnus. After *Dr. W. E. Wilson.*)

nebulæ are distributed, in a sense, contrary to the stars, being more numerous in regions poor in stars, as if they had absorbed the matter of which the stars are formed—(Flammarion, p. 656).

We will now pass some of these wonderful bodies in review, and they will thus tell their story more clearly than I can.

In Fig. 47 you see a vast, misty area without any definite shape.

In Fig. 48 we have an irregular nebula. Sir Robert Ball describes this as a disorganised nebula.

In Fig. 49 we have the great nebula in Orion. The picture is wonderful, but the object seen through the telescope is said to be most marvellous. It is the largest body in the heavens. Beneath the

FIG. 49.—The great Nebula in Orion. (Lick Observatory.)

main body are two small round bodies, which are condensing.

In Fig. 50 we have the dumb-bell nebula. You observe its mass is drawing away to each end, as if to form a double star. This mode of formation resembles the multiplication of the amœba by fission. Could anything more marvellous

be discovered by man than that, in a body tens of thousands of miles across it, the same law prevails as in the first speck of jelly which we call a living thing?

In Fig. 51 we see the spiral nebula. Thousands of these have been observed, and from this we may form some idea of the way in which the heavenly bodies began to rotate and revolve.

Fig. 52 shows the ring nebula. Perhaps, after this, we do not wonder at Saturn's rings.

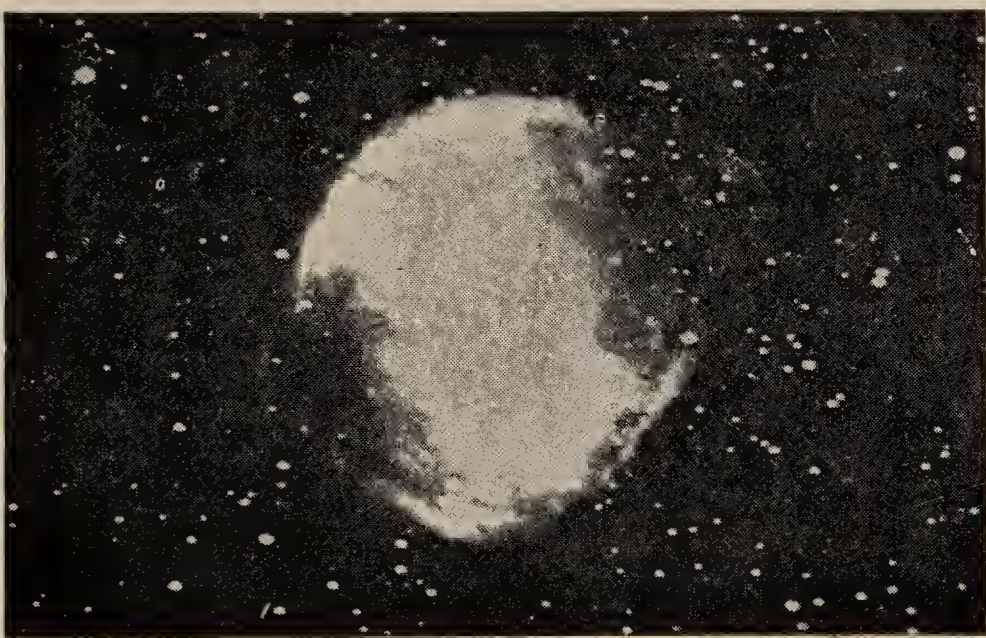


FIG. 50.—The celebrated Dumb-bell Nebula. (Lick Observatory.

Fig. 53 shows us an example of a central condensation commencing a solar focus in the centre of the nebula. Flammarion calls this primordial condensation.

Fig. 54 is found in Aquarius, and presents a sphere surrounded by a ring seen edgeways, recalling singularly the formation of a world such as Saturn. Flammarion calls this the type of a world in creation.

Fig. 55 is a nebula with the remains of detached

rings. This body is found in the constellation Pegasus, and is remarkable for the zones already

FIG. 51.—The Spiral Nebula in Canes Venatici. (After *Flammarion.*)

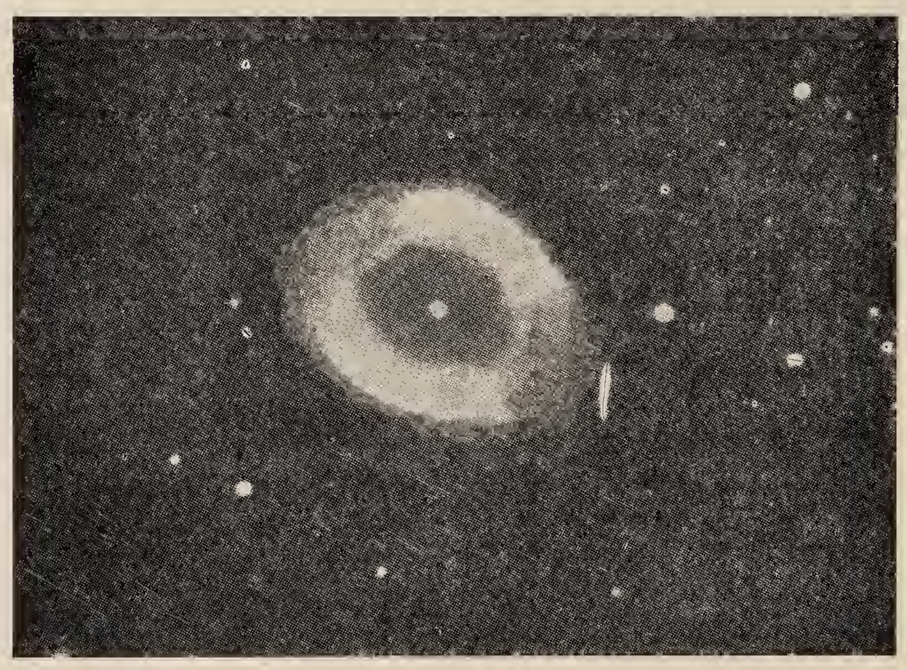


FIG. 52.—The Ring Nebula in Lyra. (Lick Observatory.)

detached from the central nucleus, a veritable sun surrounded by gaseous spirals.

Fig. 56 is the great nebula in Andromeda. If you observe it carefully, you may see dark lines or rifts round the central mist patch, and you will note that they are taking a curved form; while outside, at a little distance, you see two

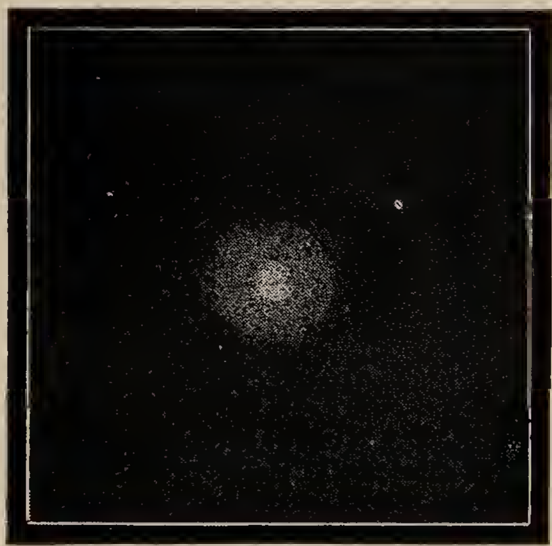


FIG. 53.—Nebula: Primordial condensation.

smaller patches. This is a photograph, and it was not until we had a photograph that the circular form of these lines could be discerned.

I will let Professor Turner, of Oxford, one of the

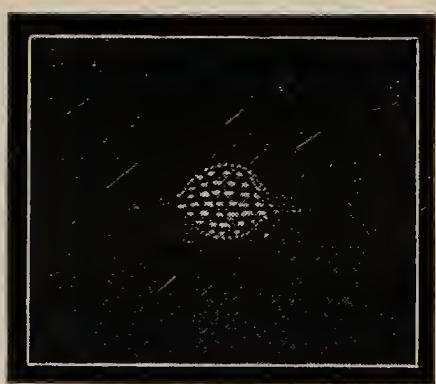


FIG. 54.—Nebula: Type of a world in formation.

foremost of living astronomers, describe the rest, lest you think I exaggerate the importance of this figure. He says (in 1901): "The rifts are really the separation between the central nebula and a

ring thrown off from it, seen in perspective; and we see here actually in the sky the state of things which Laplace suggested in his famous nebular hypothesis—a central nebula, which in its rotation throws off a series of rings, some of which break up to form satellites. There are two satellites already formed, and others are in course of formation. The system closely resembles that of the planet Saturn"—(Turner, p. 231).

Professor Turner's language is emphatic. No clearer proof than this nebula, and no clearer testimony than the Professor's, can be desired in favour of the nebular process of evolution.

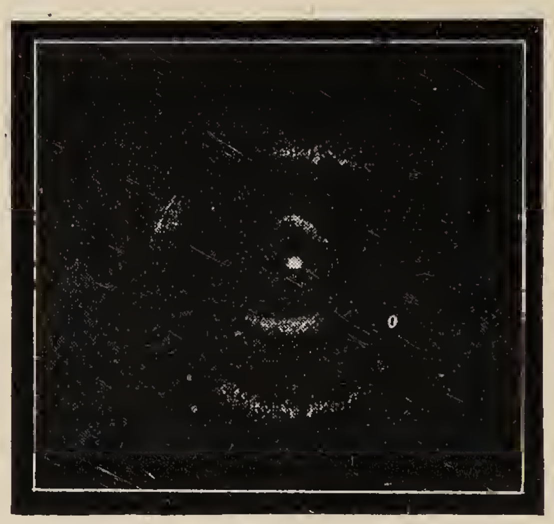


FIG. 55.—Nebula: Remains of detached rings. (After *Flammarion.*)

Sir Robert Ball, the indefatigable and eloquent Professor of Astronomy at Cambridge, has worked out the whole theory in his remarkable book, *The Earth's Beginning*, and he concludes that this hypothesis is the only reasonable explanation of the universe. There are difficulties and there are objections, but Sir Robert has answered the most serious of them.

Dr. Isaac Roberts, after considering the whole question from a very great number of photographic plates, says:—

"If the conclusions are correct which I have drawn from photographic evidence, the following would probably be the order of stellar evolution :—

"1. Dark or light aggregations of matter in globular, cometic, meteoric, or dust-like form, and in gaseous clouds scattered about, isolated, in space.

"2. Collisions between any two or more of such bodies.

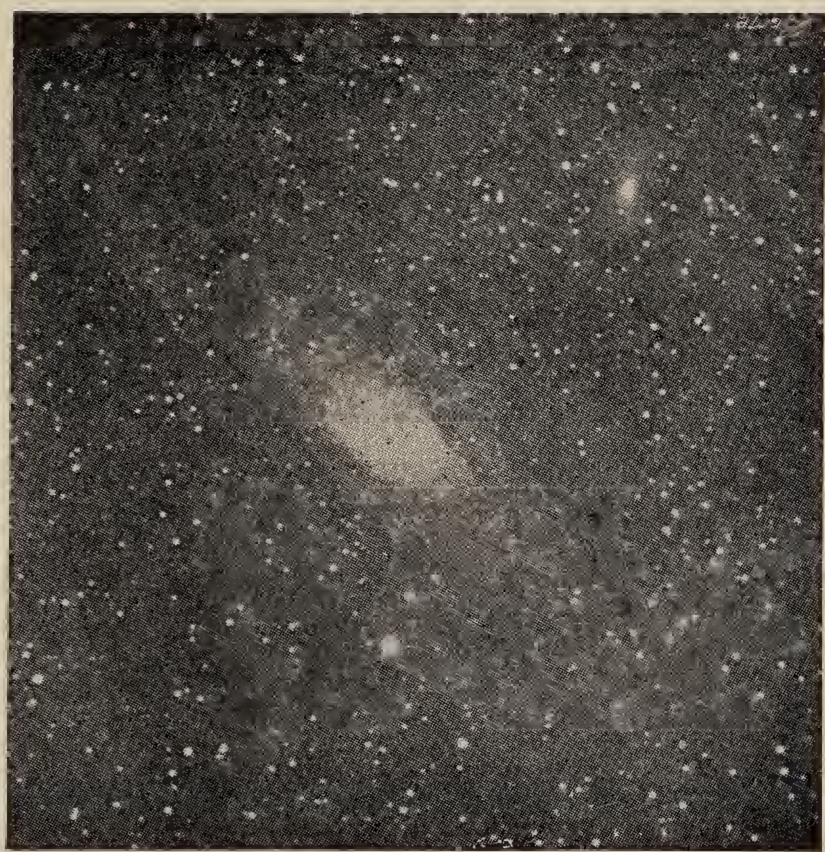


FIG. 56.—The Nebula in Andromeda. (Photographed by *Roberts*.)

"3. Re-combination of the materials, after collision, into nebulæ, mostly of the spiral type, and then into stars.

"4. Arrival again at maturity.

"5. Decay, and then the return to the epoch of quiescence preparatory to undergoing another cycle of wreckage and reconstitution.

"This is the same in principle as what we see

F

taking place on the earth on a relatively microscopic scale.

"The breaking up, by collision, of two solar systems, if the process could be viewed or photographed from the distance of Sirius, would be an event insignificant to sight, and probably too feeble in its light intensity to imprint more than a small splash on a photographic plate"—(*Celestial Photographs*, Isaac Roberts, vol. ii.).

I am bound, then, to claim that the evolution of the whole universe is proved.

I have not been able to give one-hundredth part of the evidence. I have been restricted to simple language free from technical terms, and I regret that the arguments of ten chapters cannot be put into one; but, assuredly, I shall have the sympathy of every man who has ever tried to do the same thing.

One question of greatest interest remains untouched—viz., How did matter begin? The answer is simple: *It had no beginning.* Forms may change, decay, or vanish, but matter and force are indestructible, as they revel in the eternal cycle without beginning and without end.

CHAPTER III.

GEOLOGY

IN far too brief an outline we have seen that astronomy teaches us that "the sun, moon, and stars" were evolved from a form of matter much lighter than the lightest floating cloud. Such a lesson is calculated to correct our impressions and ideas on many points.

But now we turn to our little earth to examine the outline of its history by the aid of geology.

The science of geology embraces all that can be known or inferred of our earth. The word "geology" is from two Greek words—*ge*, the earth; and *logos*, a discourse.

It is now generally admitted that, at a very early period, the earth was a molten mass—something like a very thick liquid of great heat. As this mass swung in space, it cooled on the outside. This cooled, solid portion was the original crust of the earth.

This globe (Fig. 57) is not exactly round, but rather like an orange with slightly flattened ends. That the earth is not exactly round was discovered by Newton. If you place an orange on the table, the top will represent the North Pole, and the bottom resting on the table the South Pole, while a line round the orange in the middle—*i.e.*, at its widest part, will represent the imaginary line called the equator.

But the earth does not rest on a table or on anything

else. It swings in space and turns round every twenty-four hours at a rate of more than 1,000 miles an hour. In its widest part—the equator—it is about 25,000 miles round, so that its diameter is nearly 8,000 miles; but its diameter from pole to pole is some twenty-six miles less than the other diameter. The distance from here to the centre of the earth is 4,000 miles.

FIG. 57.—The Earth.

The solid crust of the earth is about twenty-five miles thick. We do not know whether in its earliest stage the character of the solid surface was smooth or rough. We know, however, that at one stage it was an unfurnished world; it had no stratified rocks, no water, no plants, no animals.

The materials composing this earth-crust now are rocks—*i.e.*, masses of mineral matter of various kinds, as granite, sandstone, coal, clay, chalk.

Some are hard, some are soft; but, in the language of geology, they are all rocks.

Some rocks, as sandstones, limestones, always occur in regular layers or sheets—termed strata, from Latin *stratum*, anything strewn or spread out —and are therefore known as stratified rocks.

Sometimes the stratified rocks lie almost flat, as in *A* of Fig. 58; sometimes they slope at high

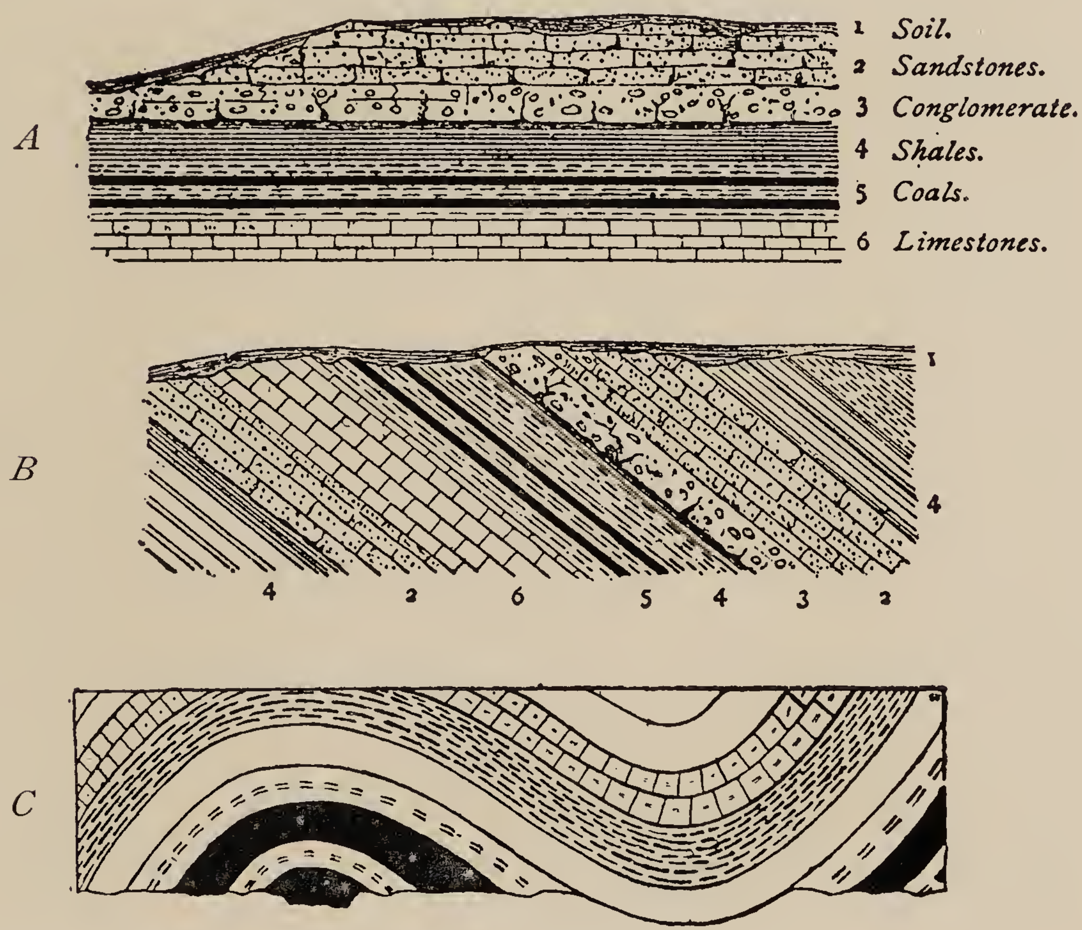


FIG. 58.—Stratified rocks.

angles, as in *B*; sometimes they are bent into arch-like ridges, as in *C*. But they can always be recognised by their parallel layers. When the stratified rocks are studied in detail they are found to resemble those masses of pebbles, sand, or mud, which, at the present time, are brought together and deposited by the water in our rivers, lakes, seas, and oceans. The geologist, therefore, ascribes the formation of the stratified rocks to the action of

water, and calls them aqueous rocks, from the Latin word *aqua*, water. Most of these rocks are called sedimentary rocks, because all matter laid down as sediment from water is deposited in layers over the floor of the receptacle holding the water.

You can see the stratified arrangement of the

FIG. 59.—The floor of a lake after a flood.

sediments; reading from the top, we have mud, sand, gravel.

We must remember the names of these most important rocks; they are called stratified, aqueous, or sedimentary.

There are vast masses and mountains of rocks of quite a different character, such as granites, basalts, etc.; these occur in irregular masses, having *no*

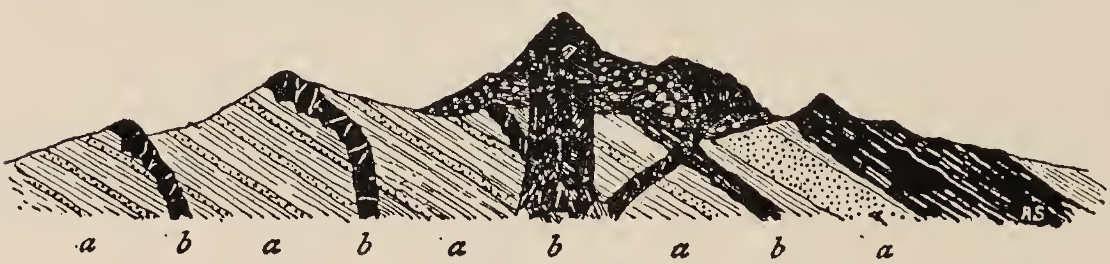


FIG. 60.—*a*, stratified; *b*, unstratified rocks.

layers, and are consequently known as unstratified rocks. These rocks often occur in great confusion among the stratified rocks, for they have no regularity of position or of arrangement; they pierce through the layers of the other rocks, or even overlie them in broad, vast masses (fig. 60).

You observe the lighter coloured layers, marked *a*. These are the stratified rocks. But among them

are dark masses, marked *b*. These are the unstratified rocks. These latter resemble in their composition and arrangement the material poured out by modern volcanoes. So the geologist ascribes them to the same agency as that which gives origin to our volcanoes—namely, to the action of the heat of the earth's interior, and they are called igneous rocks, from the Latin *ignis*, a fire.

In Fig. 61 we see the columns of the Giant's Causeway in Ireland, where the lava was poured out. The rock contracts on cooling, and usually splits into six-sided columns. Before this cause was known these and other columns were attributed

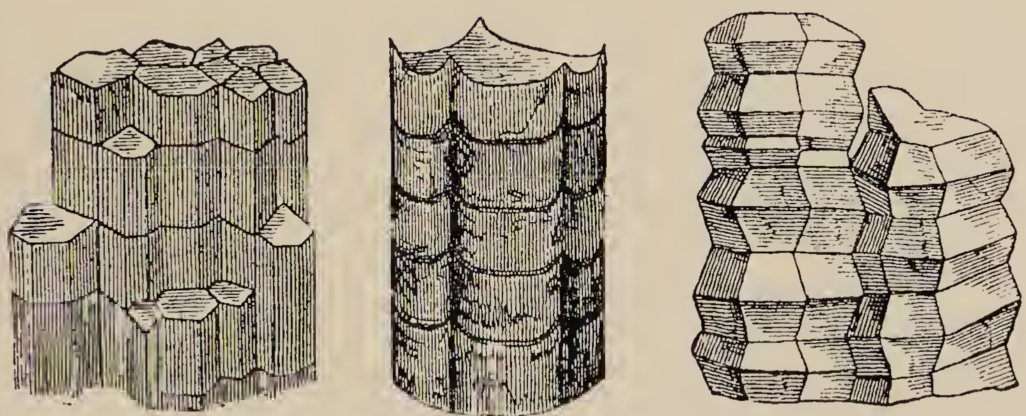


FIG. 61.—Columns at the Giant's Causeway.

to giants, or devils, or any impossible cause ; they were surrounded by mystery, and people spoke of them in solemn whispers.

For the purpose of our inquiry, the stratified rocks are the only important rocks, because the unstratified rocks contain no fossils.

We have seen that the stratified rocks are formed by the agency of water; but water is not the only force to which the early crust of the earth was exposed. Had the early crust been subject to no modifying causes, it would have remained in its simple, bare, early condition. There would have been no change of surface, no stratified rocks, no

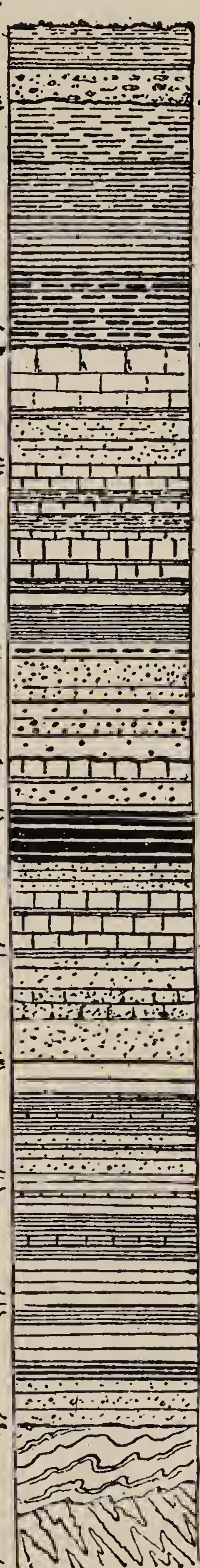
succession of plants and animals; but, from the moment the earth began to revolve round the sun and to rotate on its own axis, there has been a continuous round of change and progression; and so long as the present relations of the solar system endure, such changes will continue to be evolved. Owing to the earth's daily rotation on its slanting axis, and its annual revolution round the sun, we have day and night, summer and winter. From these alternations of heat and cold arise winds and storms, rains and rivers, frosts and glaciers, and the periodical changes in vegetable and animal life. From winds arise waves and currents; from the attractions of moon and sun arise the tides. Old rocks are wasted away and newer formations appear. Again, as a consequence of the constitution of our globe, we find that its interior is a vast reservoir of heat, the effect of which is seen in hot springs, geysers, volcanic eruptions, earthquakes. Forces under the earth and forces around the earth are continually altering its crust. These forces never cease to act day or night.

Whether the interior of this earth is solid, or a liquid, or a gas, has not yet been settled.

Our inquiry is concerned, at present, only with the crust of the earth, and this, we have seen, is exposed to so many forces of enormous power that it is never at rest. One of the great results of these forces is the formation of a third kind of rock, called the metamorphic or altered rocks. They are formed out of stratified or unstratified rocks, under the very great heat and pressure to which they have been exposed. The common roofing-slate is a good example of this kind of rock.

So now, having cleared the way in this very bald outline, we return to consider the stratified rocks.

GENERAL TABLE OF THE STRATIFIED SYSTEM AND FORMATIONS, Etc.



Groups or Cycles.	*Life Periods.*		*Systems.*	*Formations.*
Quaternary.		Anthropozoic.	Post-Tertiary. 11	Recent and Prehistoric. Pleistocene or Glacial.
Tertiary.	Neozoic.	Cainozoic.	Tertiary. 10	Pliocene. *Miocene (absent from Britain).* Oligocene. Eocene.
Secondary.	Neozoic.	Mesozoic.	Cretaceous. 9	Chalk and Gault. Neocomian and Wealden.
Secondary.	Neozoic.	Mesozoic.	Jurassic. 8	Upper Oolite. Middle Oolite. Lower Oolite. Liassic. Rhætic.
Secondary.	Neozoic.	Mesozoic.	Triassic. 7	Keuper. Bunter.
Primary.	Palæozoic.	Deutozoic.	Permian. 6	Magnesian Limestone. Permian Sandstone.
Primary.	Palæozoic.	Deutozoic.	Carboniferous. 5	Coal Measures. Millstone Grit. Carboniferous Limestone.
Primary.	Palæozoic.	Deutozoic.	Devonian. 4	Upper Devonian. Middle Devonian. Lower Devonian.
Primary.	Palæozoic.	Protozoic.	Silurian. 3	Ludlow. Wenlock. Llandovery.
Primary.	Palæozoic.	Protozoic.	Ordovician. 2	Caradoc or Bala. Llandeilo. Arenig.
Primary.	Palæozoic.	Protozoic.	Cambrian. 1	Lingula Flags. Menevian. Harlech.
Archæan.		Eozoic.	Pre-Cambrian.	Torridonian, &c. Uriconian and Pebidian. Lewisian, &c.

Fig. 62.—An ideal pillar of the stratified rocks as they might appear, if found undisturbed in any one place.

This pillar is divided by black lines where the main divisions occur. The lowest black line marks the beginning of the stratified rocks proper, which we are to study in detail. All between the lowest black line and the next black line are known as the primary or palæozoic rocks ; the next division is called the secondary or mesozoic rocks; the division above this is the tertiary or cainozoic rocks ; while the narrow part at the top is the quaternary, or Recent, or Post Tertiary rocks.

Before we enter into details we must note a few general truths.

Let us begin by noting well this statement by Professor Cole : "As a matter of fact, we know only a very small part of the vast globe on which we live. The centre of the earth lies 4,000 miles beneath us, and our mines and borings penetrate the great mass to a depth of only about a mile. But the outer layers of the earth have become wrinkled and folded, so that rocks which once lay far below the surface have been brought up within our reach. Hence in some places, immediately under the loose soil, we may find materials which were formerly ten or fifteen miles lower down ; and this enables us to say that we have some idea of the constitution of the globe to a depth of fifteen miles from the surface. It is not much, this mere outer shell, fifteen miles thick all round the earth ; but it is all we have to deal with, and we speak of this accessible region as the crust of the earth" (p. 3).

You should note, in passing, how enormous must be the forces at work which can cause great beds of rocks to be fifteen miles nearer the surface than they used to be.

The second general truth is the brilliant discovery

of the distinguished geologist, William Smith. He was born in western Oxfordshire in 1769. At the age of twenty-one Smith had discovered that the series of animal fossils succeed one another in regular order. Certain assemblages of fossil species are always, as he showed, to be found underlying other distinct assemblages ; in other words, layers of rock can be identified by the fossil remains that they contain. Hence the past history of life upon the globe is marked by a succession of animal groups, and the observation of any one of these by itself enables us to say that the rocks containing it were made at such and such a period of that history—(Cole).

Further, when once we have grasped the principle upon which the stratified rocks are formed, it is clear that in the case of several beds of undisturbed rocks the lower beds are older than the upper beds.

William Smith first made known his great discovery in 1799—*i.e.*, just over a hundred years ago.

People who expect too much from geology would do well to bear this fact in mind. We have had the key to the history of the earth's crust only about one century.

Beneath the lowest black line of the column (Fig. 62) you may see a small irregularly-shaped mass of rocks. These rocks are called Archæan, which means the ancient. They are also sometimes called the pre-Cambrian, because they come just before the Cambrian, which is the lowest layer of stratified rocks.

In one respect this column does not convey a true idea, for it does not give a correct impression of the vast depth of these pre-Cambrian rocks. Hear

what Sir Archibald Geikie says of them (p. 881): "The mere thickness and variety of the pre-Cambrian formations, together with their unconformabilities and other structural features, suffice to prove that they represent an enormous interval of time. In North America, where, so far as at present known [in 1903], they are most extensively developed, they are estimated to attain a thickness of more than 65,000 feet, or upwards of twelve miles, and have been regarded there as chronologically quite equal to the whole of the rest of the geological record."

Professor Cole says: "The Archæan era is represented by so few fossils that no division into systems can be made. But probably it covers as long a series of periods in the history of life upon the globe as all the other eras put together.......The oldest rocks of the Archæan group may, of course, represent periods before life actually existed....... The beautiful ridge of Malvern, which stands up like a blue wave against the sunset, is now known to be the relic of an Archæan mountain range. It must have been several times buried in the sea, only to reassert itself as the most striking landmark of our midlands."

We cannot emphasise this fact too strongly, because it removes one of the greatest difficulties which some people have with regard to the evolution of living forms. These objectors find in the early stratified rocks that several species of plants and animals are well developed and quite distinct, and they ask how can this be if evolution is true? Now, when they have demonstrated how many million years it took to form these hard granite masses (the Archæan rocks) twelve miles thick, then it will be soon enough to affirm that there has

not been time enough for these living species to evolve, which are found in the earliest of stratified rocks.

No one has yet been able to determine the time required for the formation of the stratified rocks; but a moderate calculation puts this time at 157 million years; and if the pre-Cambrian rocks require the same interval of time, there was another 157 million years during which the lower forms of life could evolve from the first speck of protoplasm. But some calculations put the age of the earth at a much higher figure. Even Lord Kelvin's higher limit of the time during which *living things* may have been on the earth is 1,000 million years. Well may Sir Archibald Geikie say (1903) that the physical arguments need not "prevent the geologists and palæontologists of to-day from claiming as much time as the obvious interpretation of the structure and history of the earth's crust appears to demand" (p. 81).

Surely, after this, we shall hear no more of the old difficulty, that time has not been long enough for the many species to evolve. The man who now goes on repeating this worn-out objection is not a reasoning creature, but a parrot, repeating the cry of his grandmother.

Before attempting any details, we will learn the general characters of the fossil fauna of the main divisions in this column (Fig. 62). The animals of any district are called the fauna of that district.

Beginning with the Ancient rocks, the division below the lowest black line, we learn that they are destitute of all except a few insignificant traces of organised beings. That there were different classes of living things in this enormous period is known; but the remains yet discovered are few.

Leaving these, therefore, and working our way up in the most general outline from the bottom of this pillar of stratified rocks, we learn that the vast divisions of rocks, from 1 to 6 inclusive, called the *Primary*, contain fossils belonging only to genera and species usually totally distinct from those of the present day.

The divisions 7, 8, 9, called the *Secondary*, yield fossils, all of extinct species, but more or less allied to recent forms.

Division 10, called the *Tertiary*, which comes above the chalk, contains plants and animals, partly of species now existing and partly of species now extinct.

Division 11, called *Quaternary* or recent, consists of formations now in process of deposition. This layer contains, broadly speaking, the remains of species of plants and animals identical with those living at the present day.

To begin again at the bottom of this pillar, the rocks marked 1, 2, 3 are characterised by small marine animals in shells, in a wide sense *molluscs*. There are no vertebrates found in them.

In division 4, the Devonian, *fishes* of a low order appear. In fact, this division is known as the age of fishes. In the upper layer of this division *amphibians* appear.

Division 5, the Carboniferous period, marks the age when enormous plants flourished and coal beds were formed; and there are found sharks, scaled amphibians, lizard-like fishes, and those remarkable roof-headed amphibians from which mammals have sprung.

Division 6, the Permian, shows the end of trilobites; but fish are plentiful, amphibians abound, and also lizards of many kinds.

The next great division, the *Secondary*, is known as the age of reptiles, which grew to a huge size. Bird-like amphibians appeared, and, towards the top of division 7, the Triassic, the first mammal appears. This was a marsupial or pouched animal.

In division 8, the Jurassic, we find sharks and flying reptiles, and more marsupials. Some of the reptiles weighed several tons each.

In division 9, the Cretaceous, or chalk period, we find the highest order of fishes, and wading birds with teeth; marine reptiles of some orders are becoming rare, and aquatic lizards are taking their place.

In the *upper layers of this period a group of quite small mammals appears*. At the close of this period all the flying reptiles, and dinosaurs, and most of the marine reptiles, seem to have become extinct.

We now pass to the large division 10, the *Tertiary* rocks. Here the vertebrates are essentially similar to those of the present day. All the existing sub-orders of fish are found; but the greatest change occurs in land vertebrates, mammals suddenly appearing as the dominant type. The fauna of the Jurassic group have become highly specialised.

Most important of all, there occur at the base of the lowest division of this group, the *Eocene*, two genera, whose names, when translated, are the flesh-toothed (Creodonta) and the knuckle-jointed (Condylartha), which are the ancestors of carnivors, insectivors, and hoofed animals of the present day. In the upper part of this same lowest division (the Eocene) occur placental mammals, the primitive horse (eohippus), lemurs, and marmosets.

In the second part of this division, the *Miocene*, there occur a cat, a series between dogs and bears,

a more developed primitive horse (hipparion), the mastodon, and true apes.

In the third or highest part, the *Pliocene*, occur the order of cats to which ours belongs, antelopes, typical pigs, apes.

We now reach our topmost division, the *Quaternary*. It is divided into the *Pleistocene*, or the great glacial period, and the *Recent*. Towards the close of the preceding period, the Tertiary, the climate became gradually colder, and with the beginning of the Quaternary division there set in the great glacial period or ice age. We can form no idea of this invasion of ice. It spread over Northern Europe and North America. In Europe alone it is computed to have covered 770,000 square miles; sometimes the mass of ice was 6,000 feet thick, and it was always in motion. On the Scottish mountains there are marks of the ice-sheet at heights of 3,000 feet and more. It offered one great advantage to us, because this enormous mass of moving ice overwhelmed the fauna of many districts, and so left us some relics by which to re-construct the history of the earth's inhabitants. It is a long and interesting story; but, for us, it is enough to remember that, as Sir Archibald Geikie says, "It is quite certain that man co-existed with the fauna of the Pleistocene series"—*i.e.*, man lived with the animals of the ice age.

Now, having arrived at man after this very rapid survey, let us inquire whether it tells for or against the theory of evolution.

We have in geology a science dealing with such millions of years that the mind is baffled in trying to comprehend them. Do we find a record here contrary to the doctrine of evolution? Of course,

low forms of living things, mere specks of jelly, are not likely to have left a record in solid rocks under a pressure of many tons; but when we discover animals with shells, or bones, or scaly coverings, do we find the highest in the lowest rocks, and only the simpler forms in the most recent rocks? By no means. This would be to invert the order of nature. No, the farther we go from the present time into the depths of rocks, the more the animals are unlike those now found living in the world. The farther back we go, the simpler are the living forms shown to have been. We trace these rocks

FIG. 63.—The Eozoon Canadense. 1, the layers natural size; 2, the tubes magnified 100 diameters.

up for millions of years before we meet with a vertebrate animal, and, as we should expect, that animal is a fish; then we trace other rocks up for tens of millions of years before we meet with a mammal. This looks suspiciously like evolution.

At any rate, we have cleared away one theory: there is no evidence whatever in favour of the supposition that all animals, or even the same groups of animals, were made at the same time.

In fact, everything we have seen is in flat contradiction to this supposition. We have seen that races of animals become extinct, that species which survive through long periods are so changed and modified that we are compelled to classify them as new species.

ARCHÆAN AND PRE-CAMBRIAN ROCKS.

In these rocks before the Cambrian period perhaps no true fossils have been found; but in certain pre-Cambrian rocks in Canada the curious layers represented in Fig. 63 were held to be of organic origin, and therefore true fossils. To these bodies was given the title Eozoön Canadense (or Dawn animal of Canada).

The two pictures are of the same layers of rock, only in the one on the right the little tubes have been magnified 100 times. Many battles have raged over these tubes. They were supposed to represent small animals, and, in some mysterious way, the fact that these small animals lived at such an early period was supposed to prove the doctrine of evolution to be false! However, it has now been demonstrated that these tubes are not animal remains at all, so the doctrine of evolution has escaped destruction.

Now we will look at some of the specimens of the various periods in rapid succession, with but little comment, as they will often interpret themselves, if you bear in mind that we are to work from the ancient rocks up to the formations of our own time.

CAMBRIAN DIVISION.

We begin with small shell animals from the sea; and the point to note is how very slowly those

animals appear which at all resemble those living around us now.

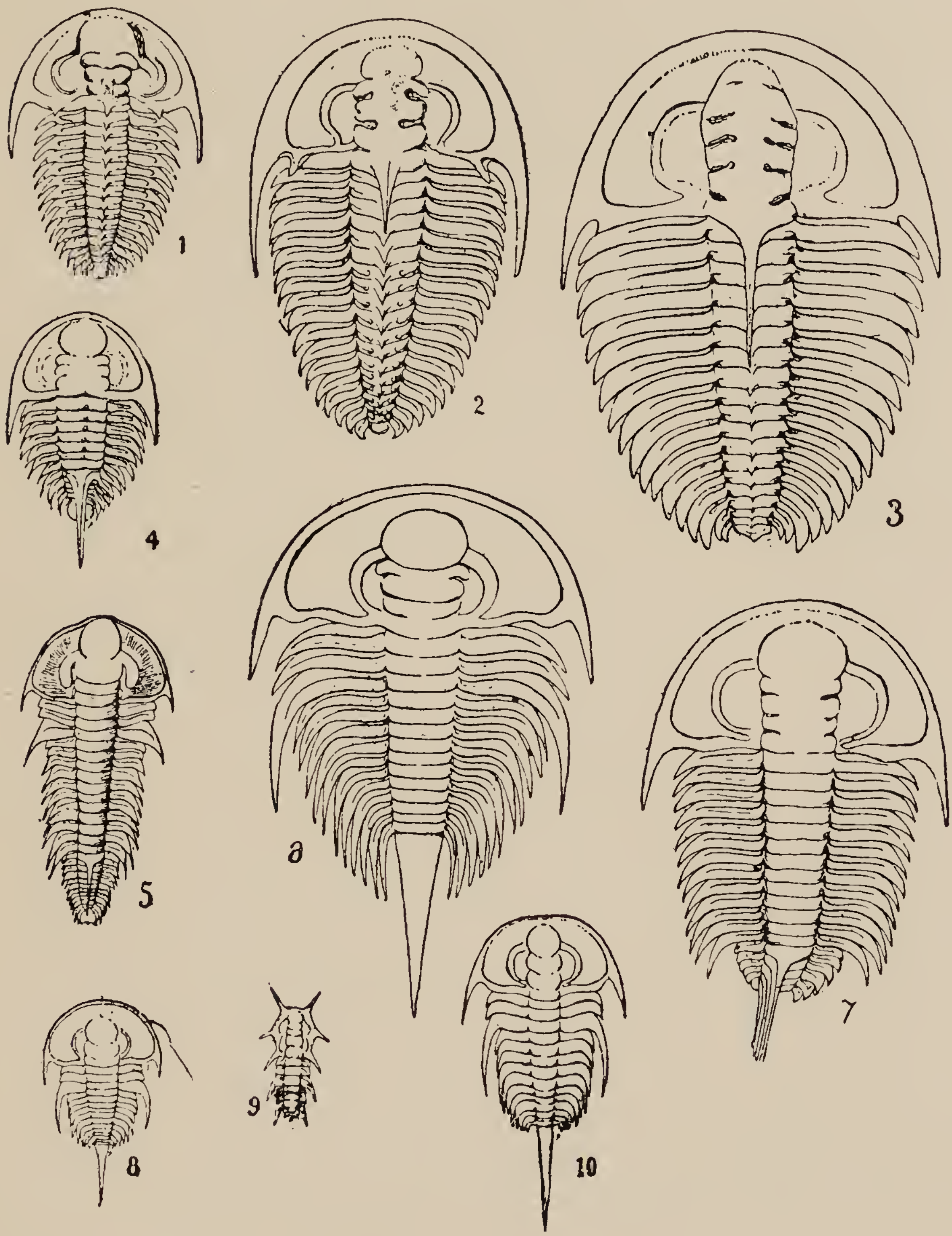
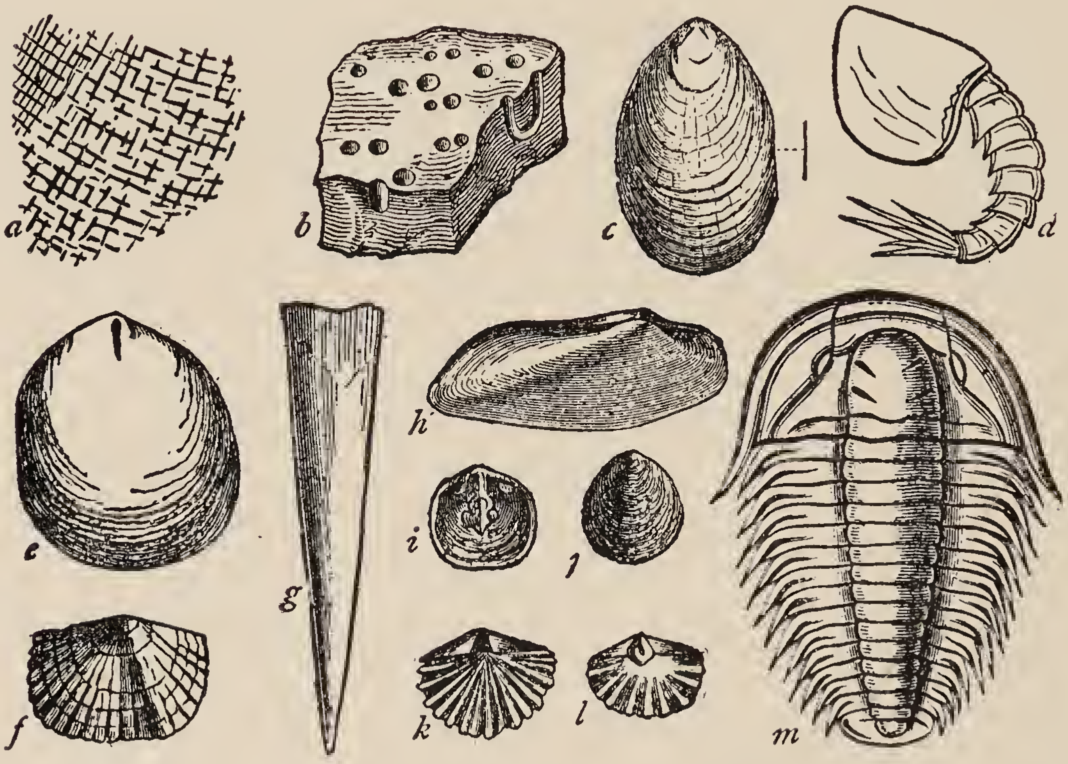


FIG. 64.—A group of Cambrian Trilobites. (The Olenellus.)

In Fig. 64 we see the most abundant animals of that earliest period.

It is not necessary to learn the names of the

fossils in Fig. 65 now. You can see they were small, low forms, enclosed in shells.



G. 65.—Other Cambrian Fossils.

SILURIAN DIVISION.

In Fig. 66 you may see the trilobites are changing considerably in their form.

Figures 66, 67, 68 represent an enormous period of time, and yet you see that only simple forms of life are found.

DEVONIAN DIVISION.

Figure 69 is from the Devonian or old red-stone rocks. It is a vertebrate, but it has no jaws, and in this and other ways is possibly allied to the lampreys.

In Fig. 70 the one at the top and the middle one are partly covered with shell, showing the power of a shell-forming environment. During this age (the Devonian) fish were largely developed, and many

other forms (some almost like existing fishes) could be shown.

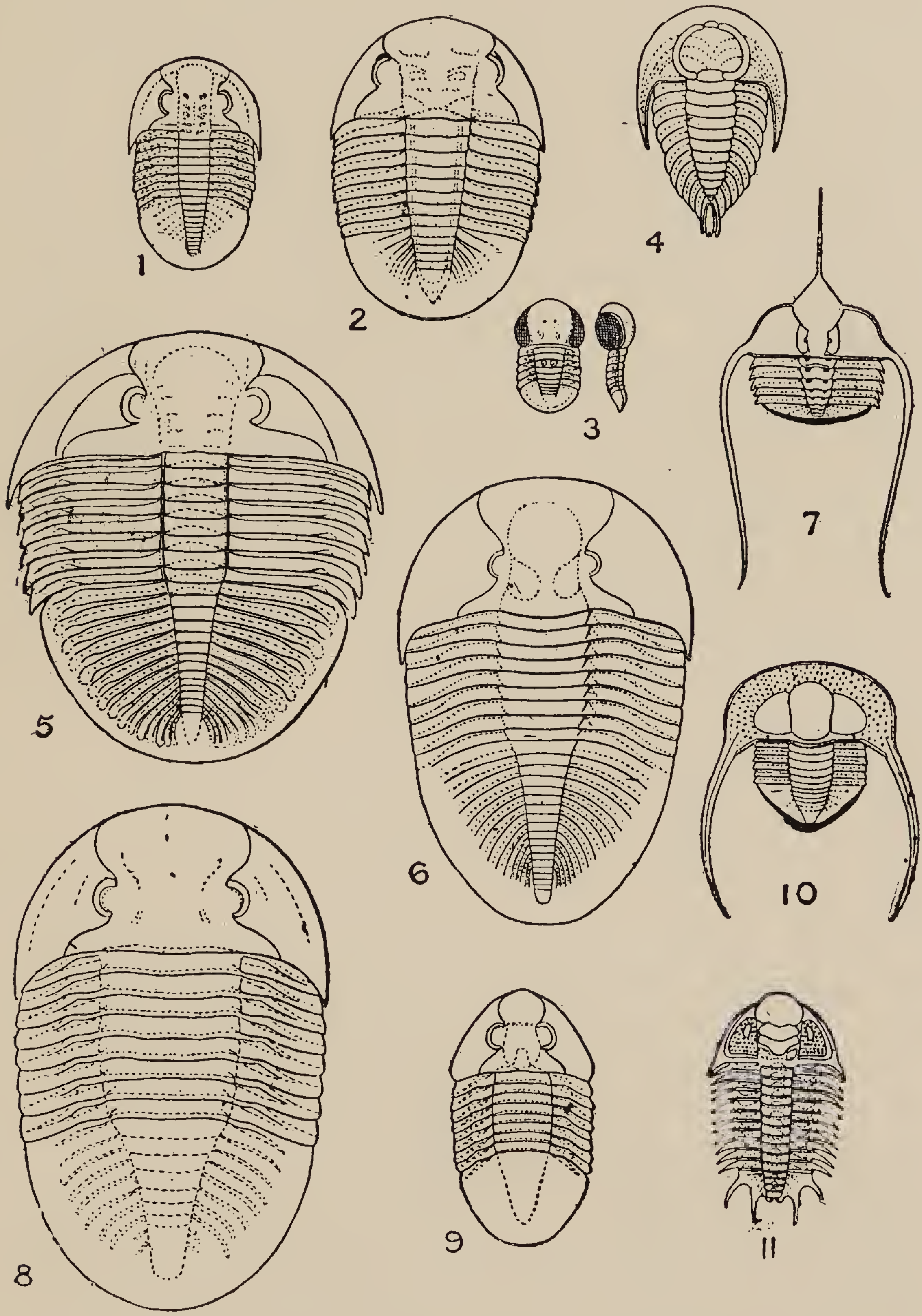


FIG. 66.—A group of Lower Silurian Trilobites.

Sharks abounded in this period, and Fig. 71 shows one of these early forms.

Fig. 72 shows a Crustacean. Modern crustaceans include lobsters, crabs, cray-fish, shrimps, etc.

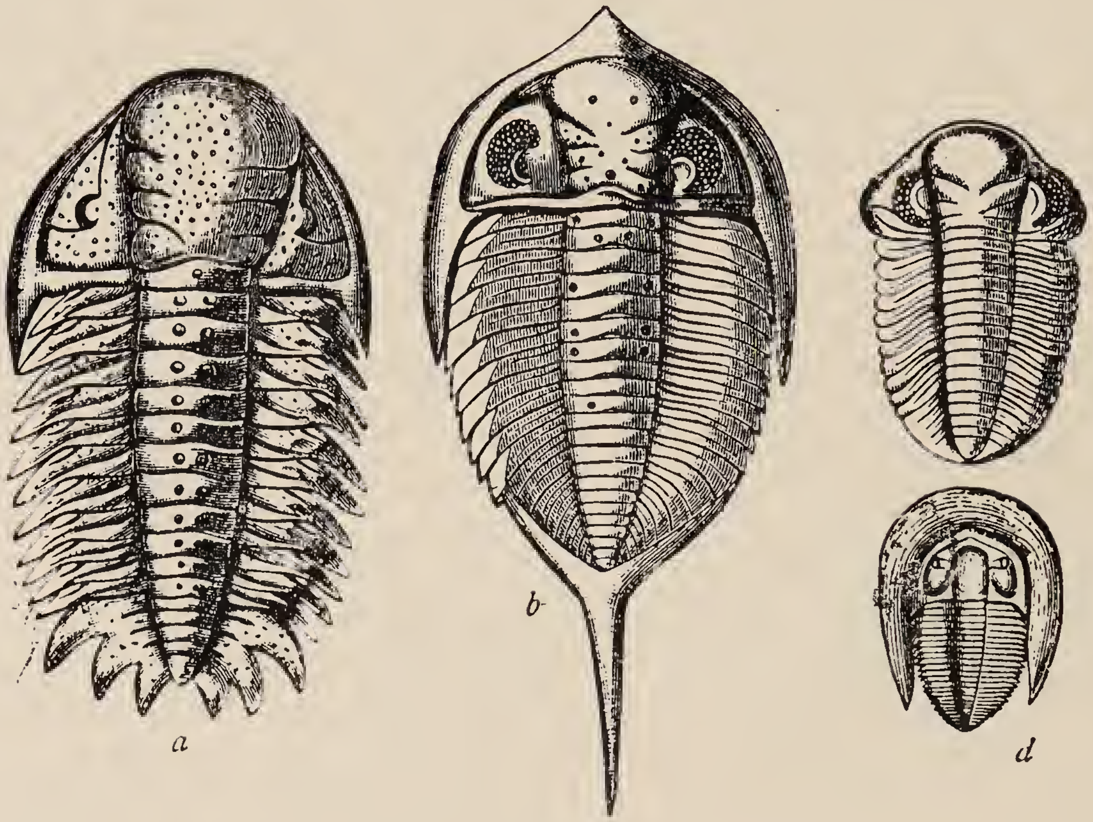


FIG. 67.—Upper Silurian Trilobites.

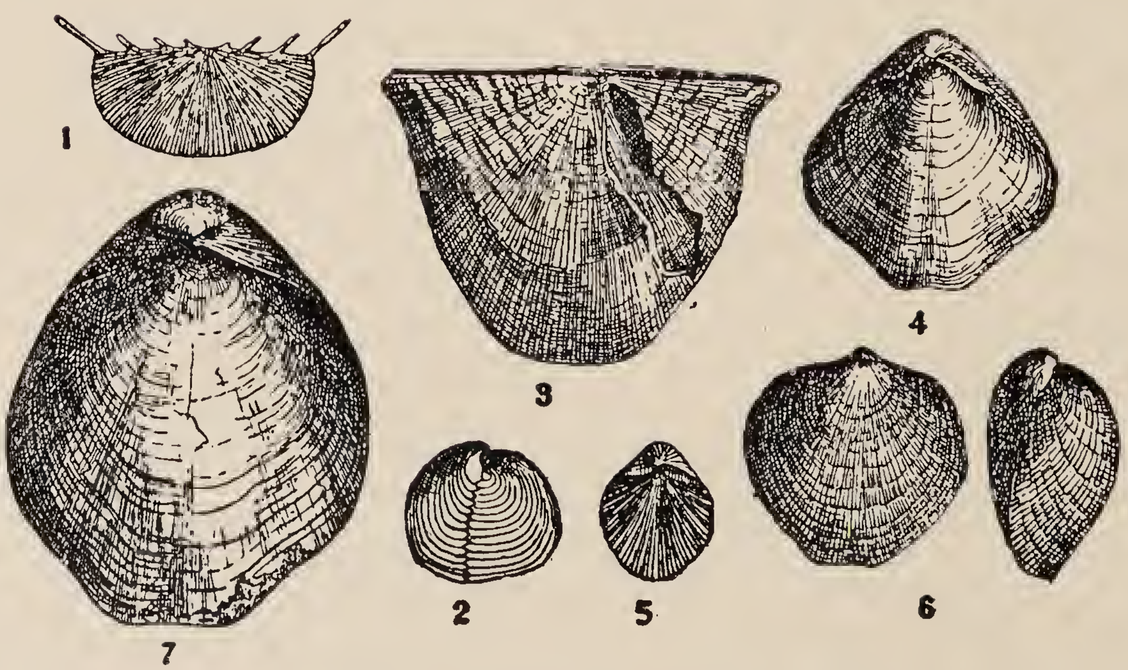


FIG. 68.—Upper Silurian Molluscs. (Brachiopods.)

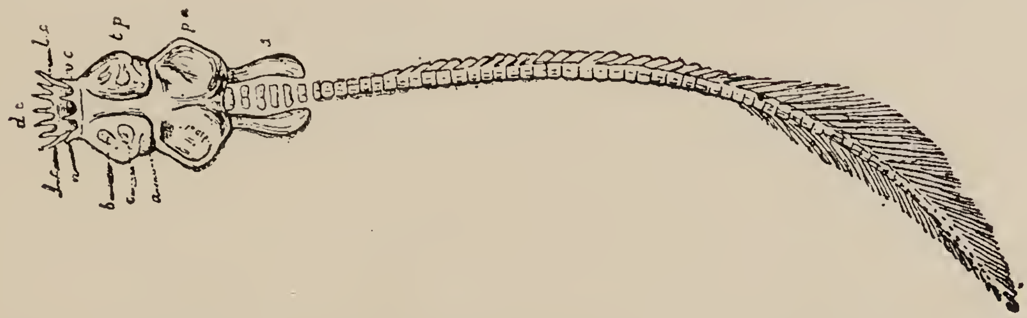


FIG. 69.—The earliest known form of Fish. (Palæospondylus.)

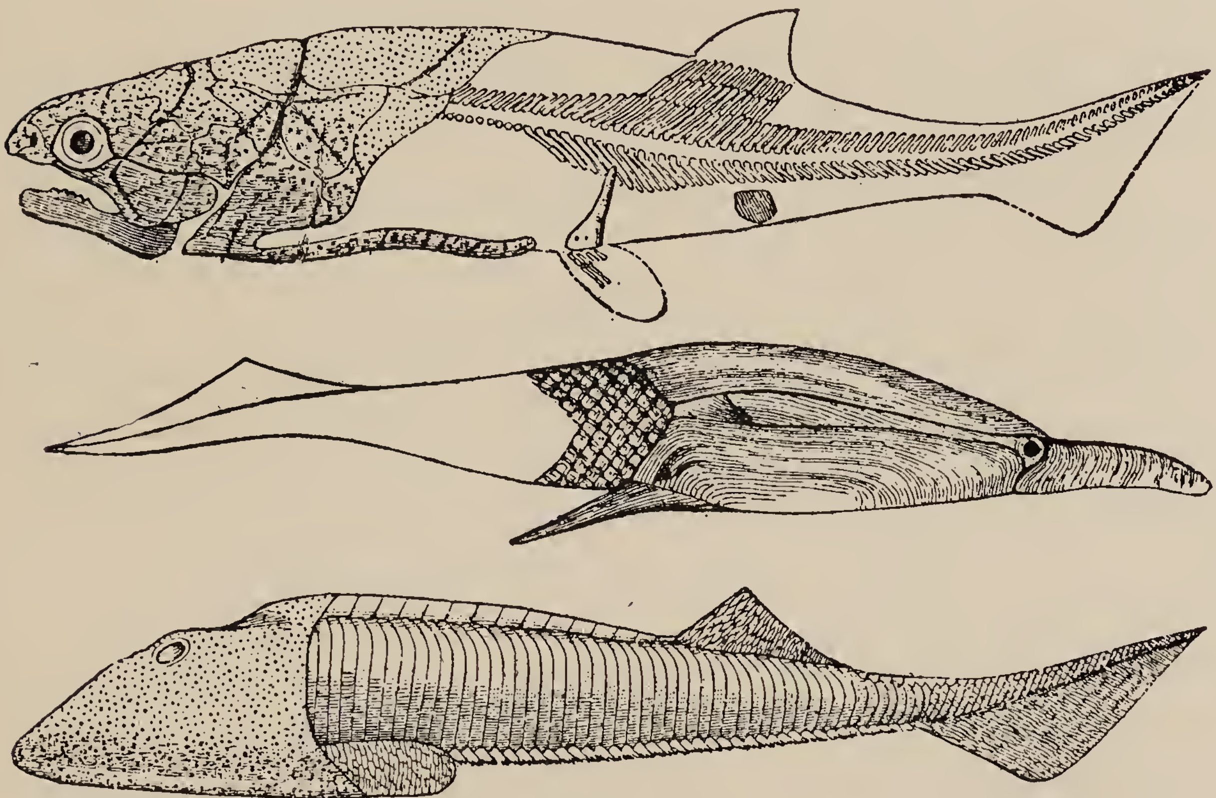


FIG. 70.—Three early forms of Fish.

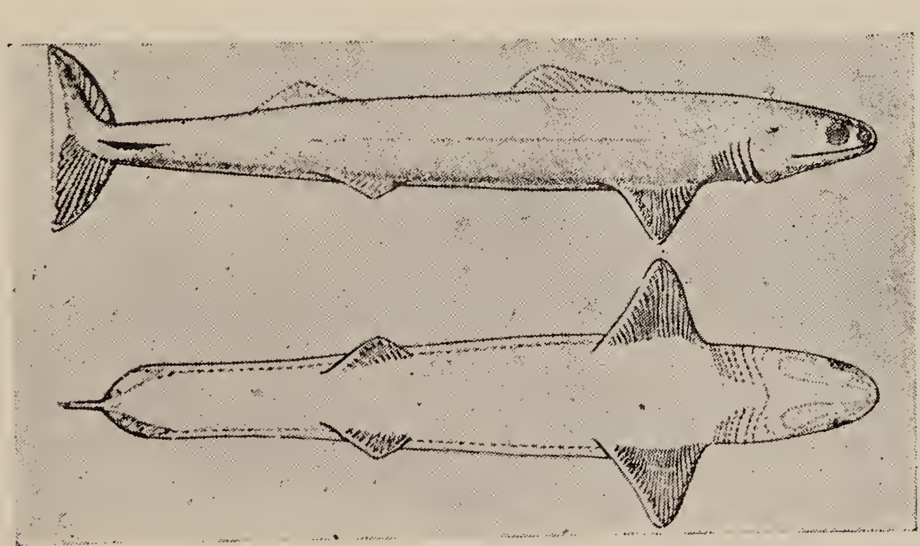


FIG. 71.—Cladoselache fyleri. The upper one is the lateral view; the lower the ventral view.

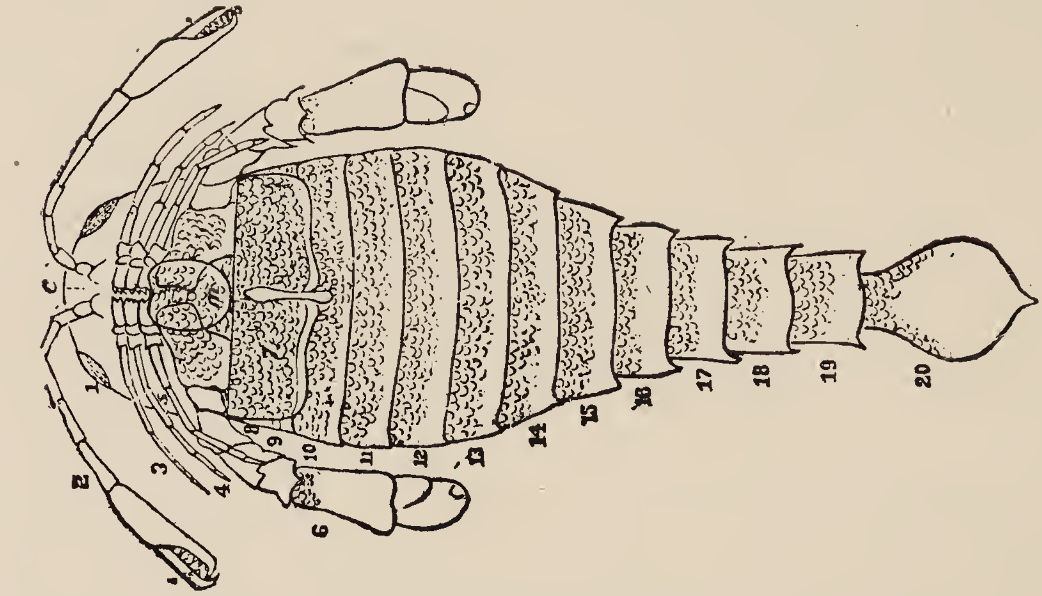


FIG. 72.—One of the order of Crustaceans.

CARBONIFEROUS DIVISION.

We pass up to the Carboniferous period, the age of enormous vegetation, when coal was formed. The small shell-covered animals continue, though under altered forms and new species. Many orders of fish occur with more highly-developed structures,

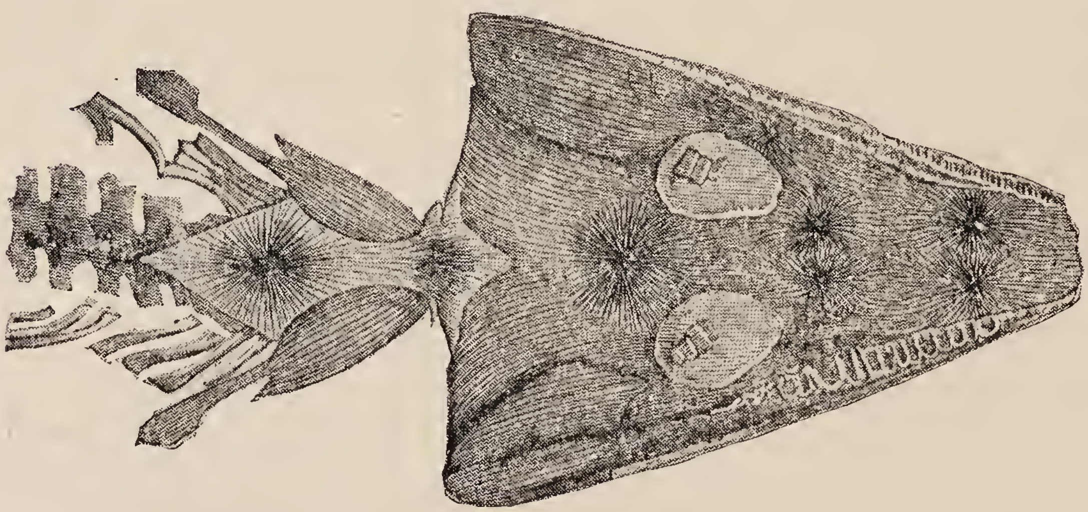


FIG. 73.—The Head of the celebrated Amphibian, the Archægosaurus.

but the marvel of this period is the appearance of *Amphibians*.

In Fig. 73 you must recognise at once that a new group of animals has arrived.

PERMIAN DIVISION.

Fig. 74 is a good representation of the roof-headed amphibians (Stegocephali), of the Permian period.

The utmost interest attaches to these amphibians, for from some of them came the reptiles which gave rise to mammals.

It is *not* to be supposed that any of these great divisions of rocks are marked off by some impassable barrier; yet, though the fauna of the upper layer of one division may closely resemble those in the lowest layer next above, the groups as a whole are distinct.

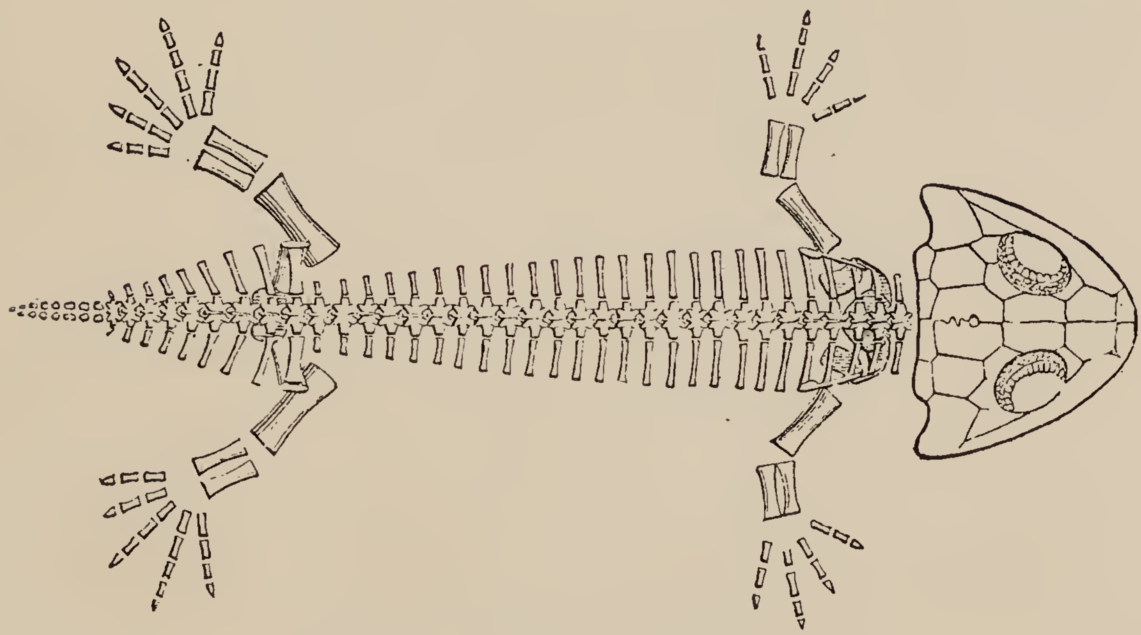


FIG. 74.—The Branchiosaurus.

TRIASSIC DIVISION.

We now pass from the Primary division to the Secondary.

The lowest group of rocks in this Secondary division is called *Triassic*, and I will show you the reptiles from which came mammals.

Fig. 75 shows one of the great group (the Theromorpha), called the mammal-shaped reptiles.

The lowest division of these reptiles is well represented here. Note what a crude, raw specimen he is.

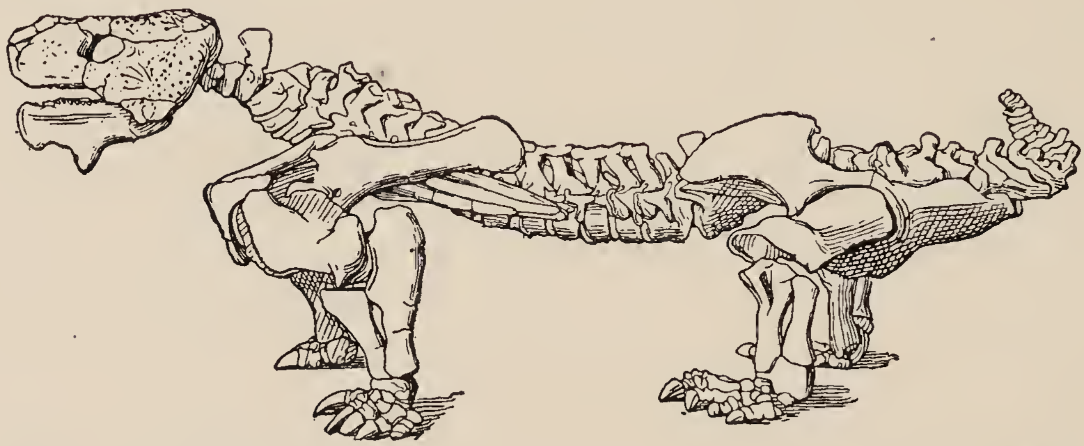


FIG. 75.—The Pariasaurus baini, from the Karoo formation, South Africa.

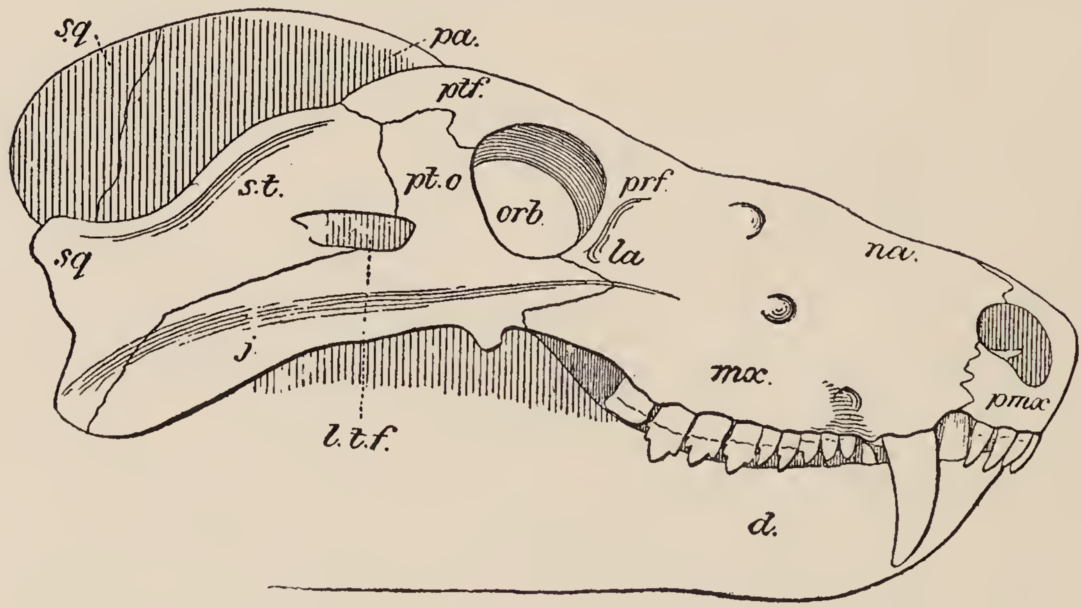


FIG. 76.—The Dog-jawed Reptile, Cyno-gnathus.

Fig. 76 is a higher example of the group shown in Fig. 75.

Fig. 77 is the Weasel-shaped Reptile. Above, is the side view of the skull, beneath, the upper and lower view of the same, with a tooth lying between them. Note the terribly ferocious aspect of this skull, and you will see it is as deadly as the worst of our carnivorous animals.

The age of this group of reptiles is so vast that I can use no figure of speech to bring it home to you.

The stem-forms of the mammals must be sought in the order of reptiles represented in Figs. 75, 76, 77.

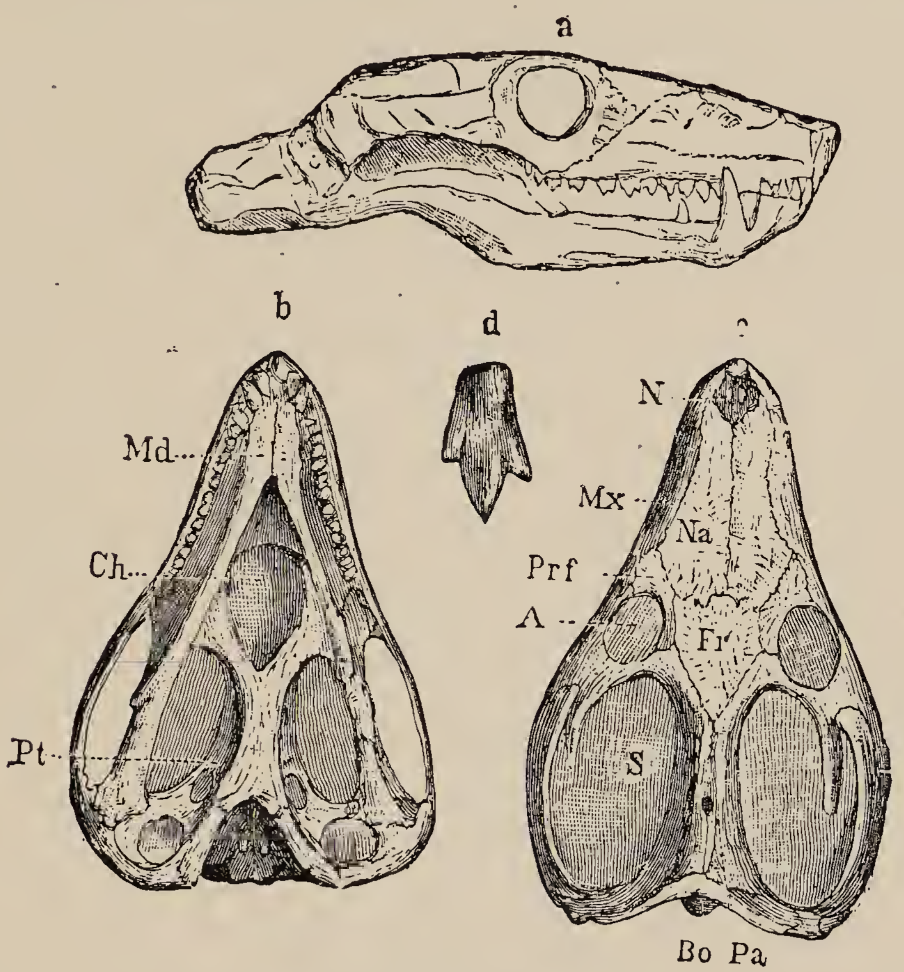


FIG. 77.—Skull of a Triassic Theromorphum *(galesaurus planiceps)*, from the Karoo formation in South Africa. (From *Owen.*) *a* from the right, *b* from below, *c* from above, *d* tricuspid tooth. *N* nostrils, *NA* nasal bone, *Mx* upper jaw, *Prf* prefrontal, *Fr* frontal bone, *A* eye-pits, *S* temple-pits, *Pa* parietal eye, *Bo* joint at back of head, *Pt* pterygoid-bone, *Md* lower jaw.

JURASSIC DIVISION.

The next division of the Secondary rocks is called the Jurassic; its reptiles are noted for their huge size.

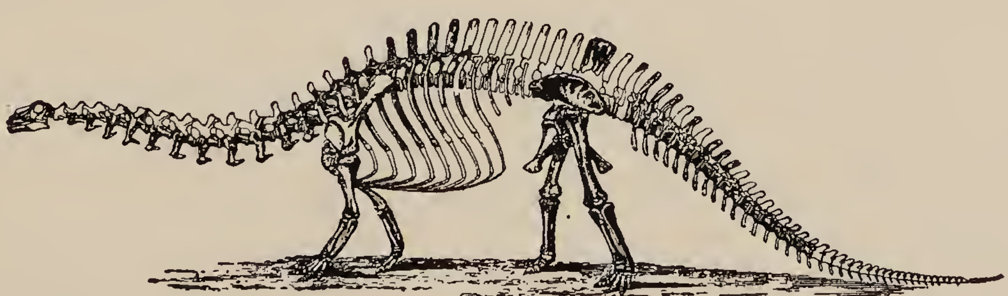


FIG. 78.—The Brontosaurus.

The Brontosaurus (Fig. 78) was one of the largest of land animals. Its length is estimated

FIG. 79.—The Megalosaurus.

at fifty feet, and its weight, when alive, at twenty tons.

The Megalosaurus is another of those gigantic land animals for which this period is famed.

Figs. 78 and 79 are examples of huge reptiles which throng the Jurassic period.

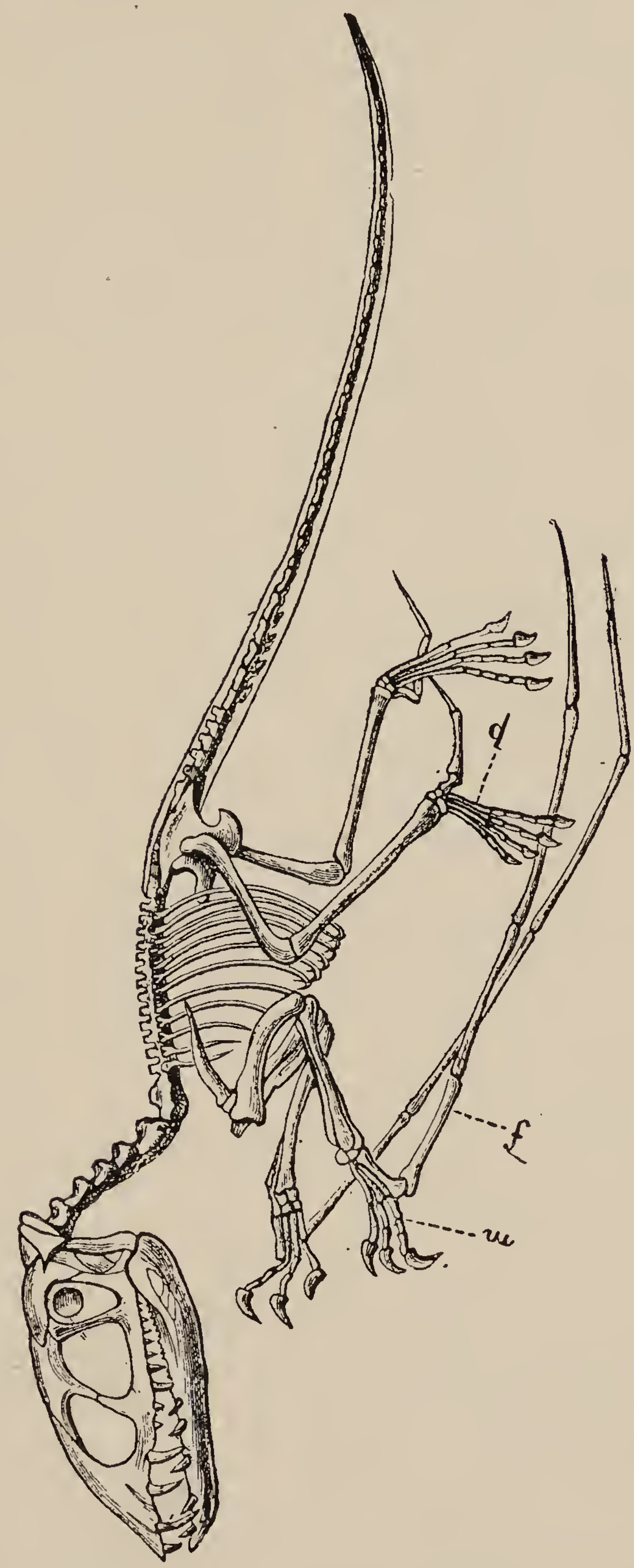


FIG. 80.—The skeleton of a large flying reptile, the Dimorphodon.

These animals were ferocious and utterly brutal, and held their sway for a time ; but in this period

there appeared one of the lowest and earliest mammals belonging to the order of the pouched animals (Marsupials). Mammals were destined to change the living Orders of the world. Lizard-tailed birds also appeared at this period.

CRETACEOUS DIVISION.

The topmost division of these Secondary rocks is the great chalk age, called *Cretaceous*.

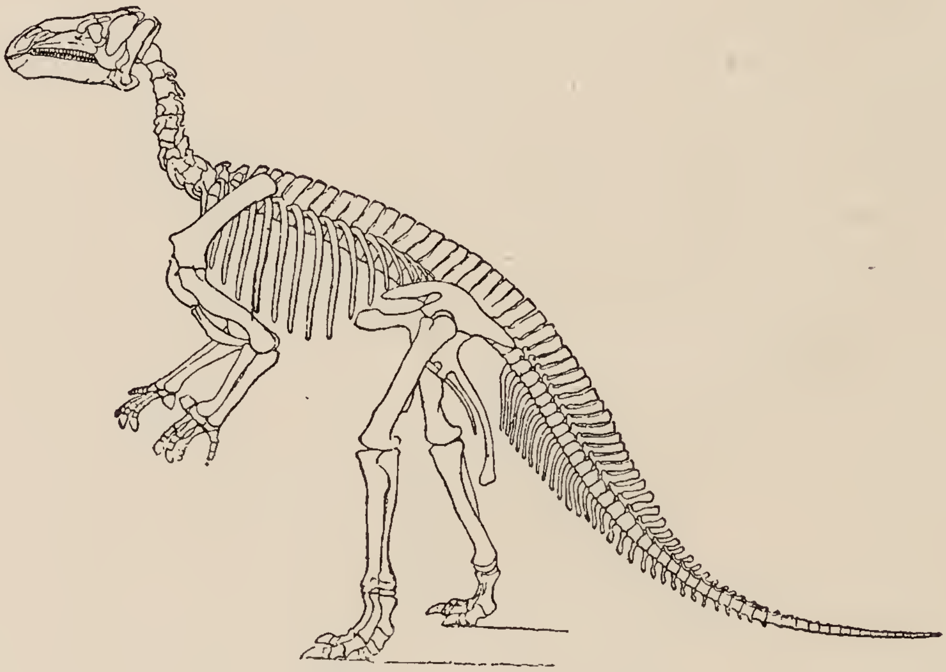


Fig. 81.—The Iguanodon.

This marks very little change from the preceding group.

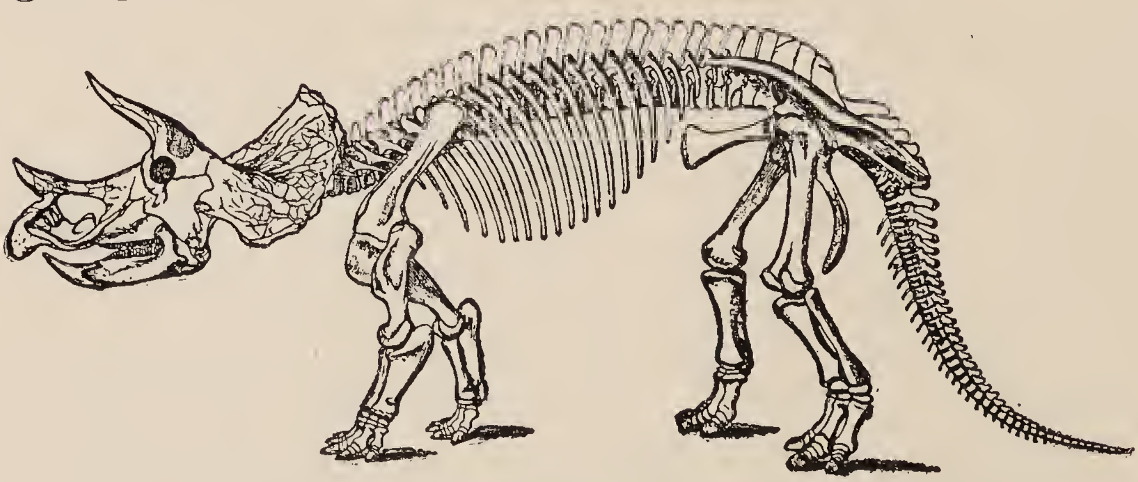


Fig. 82.—The remarkable Triceratops, the three-horned.

Fig. 82 is certainly a different being, and may represent the animals that came in as the Dinosaurs died out.

Figs. 83 and 84 are two very remarkable birds of the Cretaceous period.

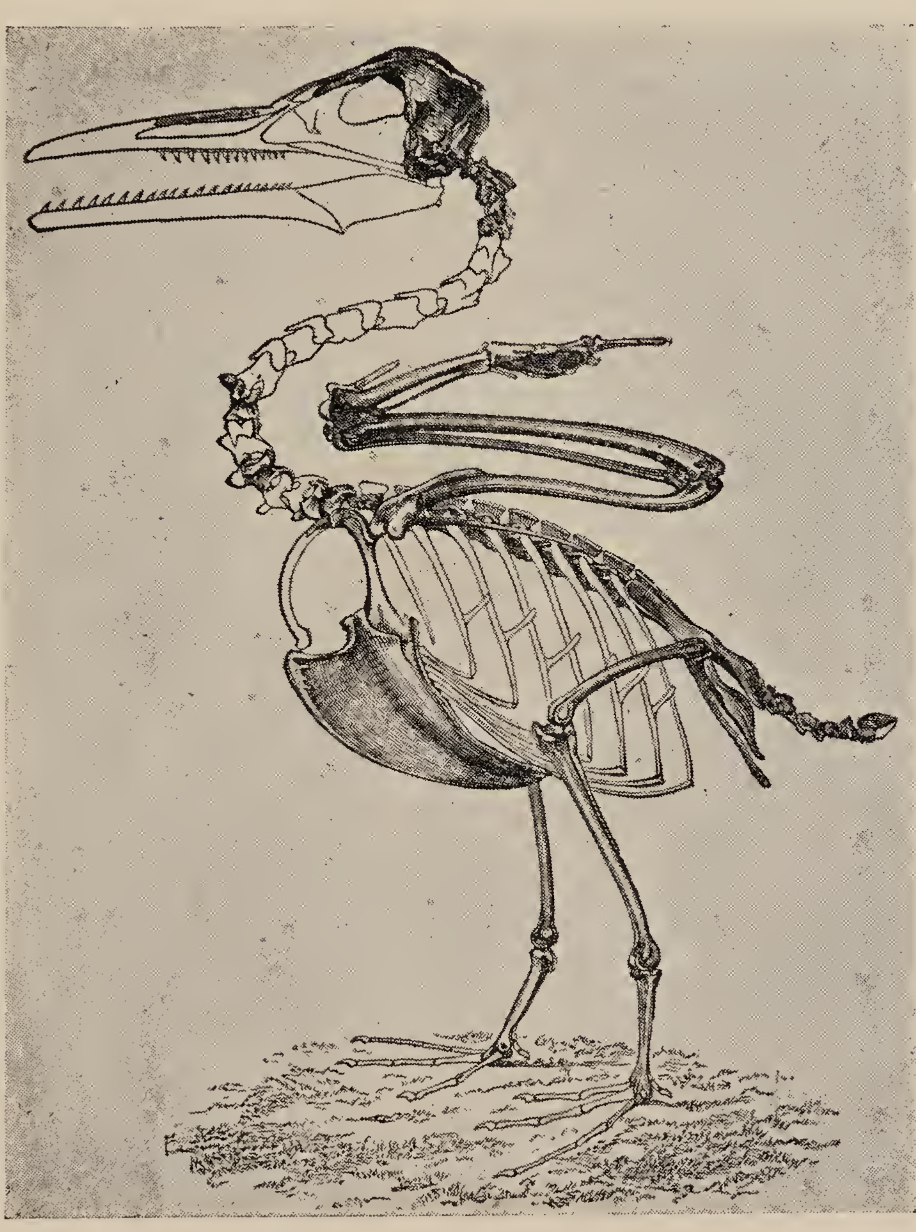


Fig. 83.—Ichthyornis victor; restored.

They have points resembling the lizard, and you may see they have teeth.

Many mammalian forms have been discovered, several of them small, pouched animals, and some which seem to be allied to the duck-mole, while

possibly others may belong to the order of insectivorous animals.

We pass now to the third great division of rocks—the *Tertiary*. Here we find a striking change in the fauna, brought about by the change of the crust of

FIG. 84.—Hesperornis regalis.

the earth. We pass from a great, massive uniform formation, like the chalk which had been deposited in the waters of open seas covering vast areas of country, to thin beds of sandy, shaley, or calcareous rocks.

The large families of huge reptiles have practi-

cally disappeared, and, where the bed of the sea used to be, there are now millions of miles of dry plains, on which roam a race of animals such as the world had never seen before. Hence this period is called the New-life (Cainozöic) period.

The reptiles are mainly tortoises, turtles, crocodiles, and sea-snakes. The rule of the reptile is over.

EOCENE DIVISION.

In the lowest group of this division, the *Eocene*, we find the ruling animals are mammals.

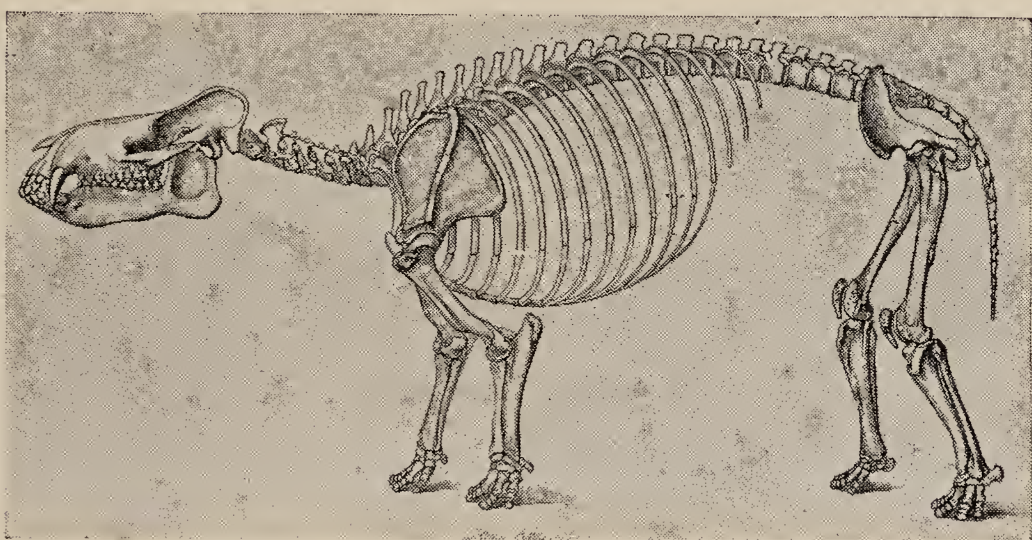


FIG. 85.—The Coryphodon.

FIG. 86.—The Hyracotherium (or Protorohippus).

The Coryphodon is an animal rather like the modern tapir.

The Hyracotherium is a shape intermediate between the hog and the celebrated Hyrax—(Geikie).

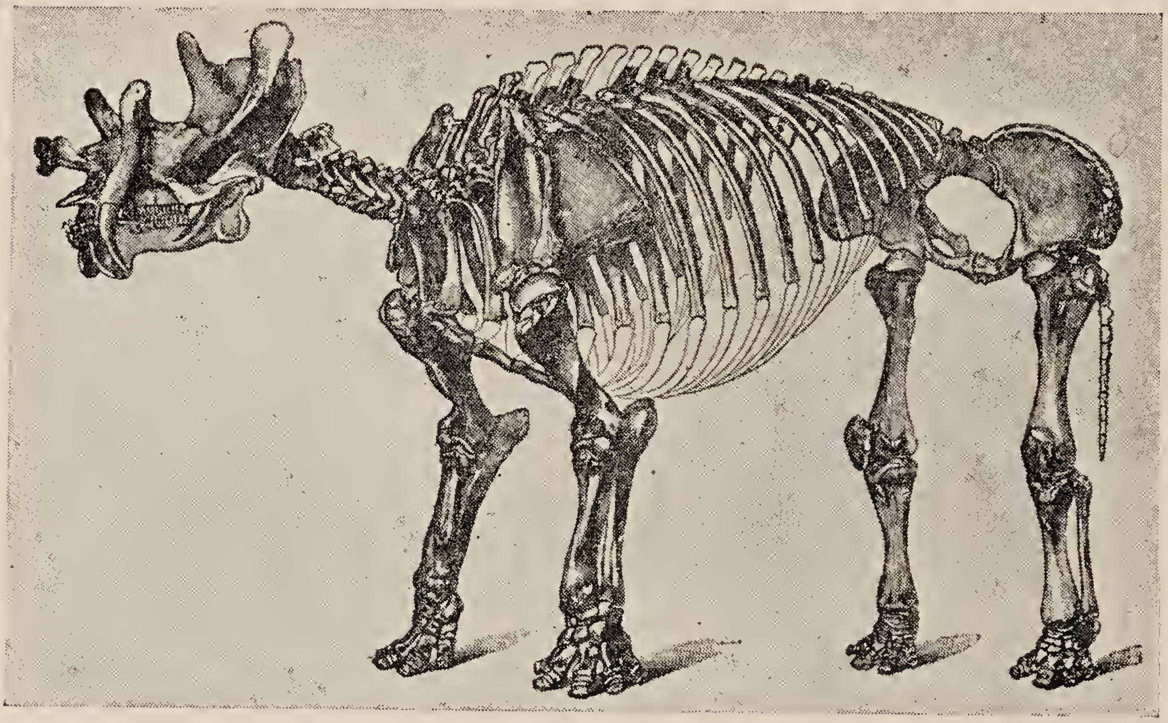


FIG. 87.—The Tinoceras; restored.

FIG. 88.—The Skull of the Adapis.

The Tinoceras must serve to represent other groups.

Its own group is remarkable for wonderful creatures with extraordinary names. "These animals possessed, according to Marsh, the size

of elephants with the habits of rhinoceroses, but bearing a pair of long horn-like prominences on the snout, another pair on the forehead, and a single one on each cheek."

Not only are the insectivorous animals found, but several small animals of the lemur type, the earliest representatives of the tribe of monkeys.

The Adapis was one of the early lemuroid animals.

MIOCENE DIVISION.

We pass now to the next group of rocks in this division, called the *Miocene*.

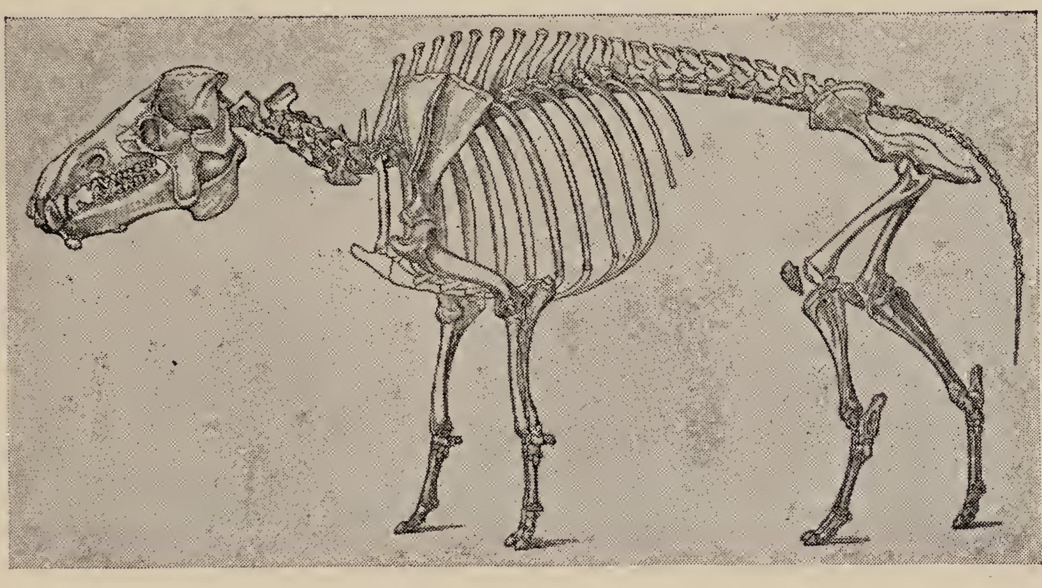


FIG. 89.—The Elotherium.

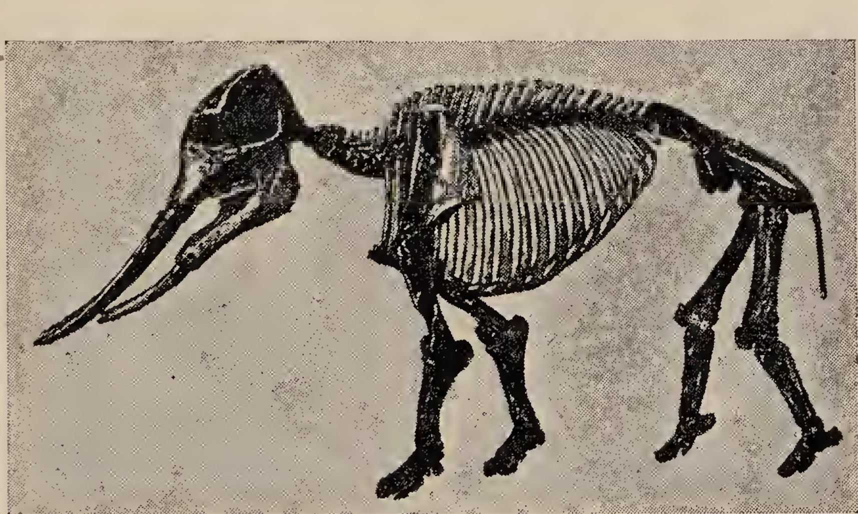


FIG. 90.—The Mastodon.

The Elotherium is a large pig-like animal, which,

you should note, has learnt to walk on its toes. It is found in the Miocene, both of Europe and North America.

The Mastodon is one of the most remarkable creatures of the fauna of these rocks. It was closely allied to the elephant.

The wonderful flesh-toothed animals (Creodonta), ancient Carnivors, appear for the last time in the Miocene.

The middle Miocene is remarkable for a series of genera intermediate between the dogs and bears, and also for *true apes*.

PLIOCENE DIVISION.

We next come to the uppermost group of rocks in the Tertiary Division, called the *Pliocene*.

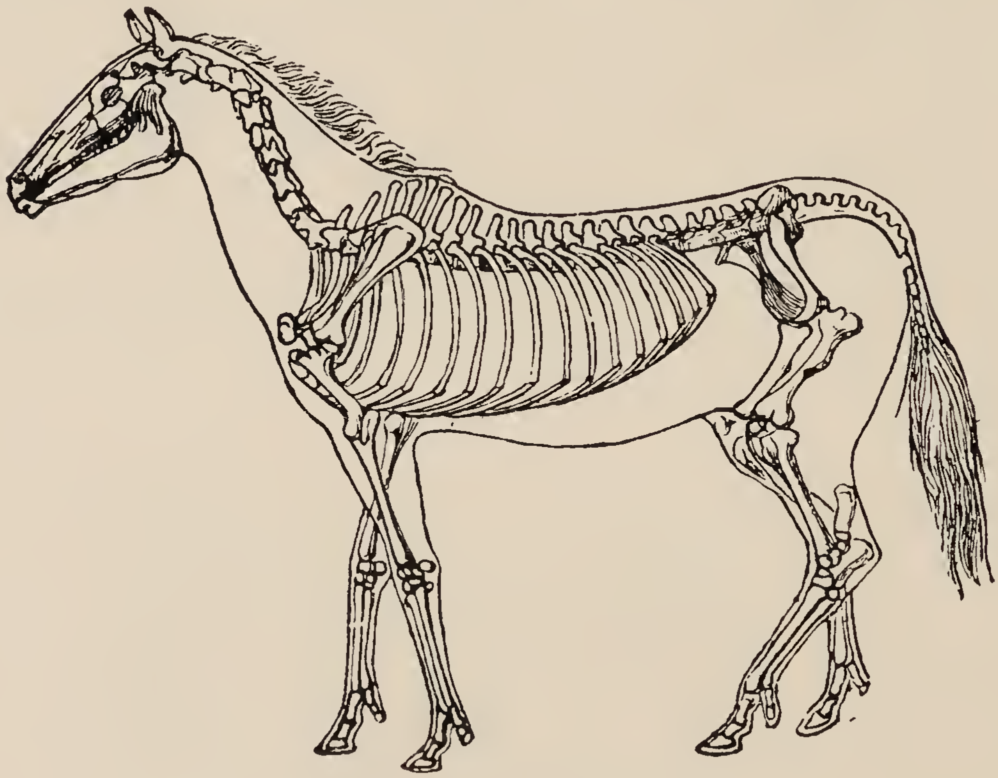


FIG. 91.—The Hipparion.

Here the mastodon flourishes, the elephant does not appear till late in the period, and typical pigs are also found.

The Hipparion is one of the ancestors of the horse, which appeared in the Miocene, and is

abundant in this division. Species of the true horse are also found.

Fig. 92 shows one of the long-nosed apes, found at Pikermi, near Athens.

FIG. 92.—The Mesopithecus.

PLEISTOCENE DIVISION.

We have now looked at the series of animals from early Cambrian times to the great ice age, which forms the lowest part of the Quaternary rocks. This ice age is often called the *Pleistocene* period.

True apes appear first in the Middle Miocene of Europe. Most European fossils can be referred to the family Cercopithēcidæ, which includes all the living Old World apes except the Simiidæ—*i.e.*, the gibbons, orangs, chimpanzees, and gorillas. The oldest fragments are jaws and teeth of a comparatively large animal from the Middle Miocene of Tuscany. The best known form is the Mesopithecus (Fig. 92) of the Lower Pliocene.

Fragmentary remains of apes are known from the Pliocene and Pleistocene of India, the most interesting being typical portions of the dentition of baboons (cynocephalus), which are now restricted in their range to Africa and Arabia.

Of the immediate ancestors of man, family

Hominidæ, scarcely anything is known from fossils.

"The oldest known traces of a man-like skeleton seem to be an imperfect roof of a skull, two molar teeth, and a diseased femur, from a bed of volcanic ash containing the remains of Pliocene mammals near Trinil, in central Java. These are believed to belong to one animal, which has received the name

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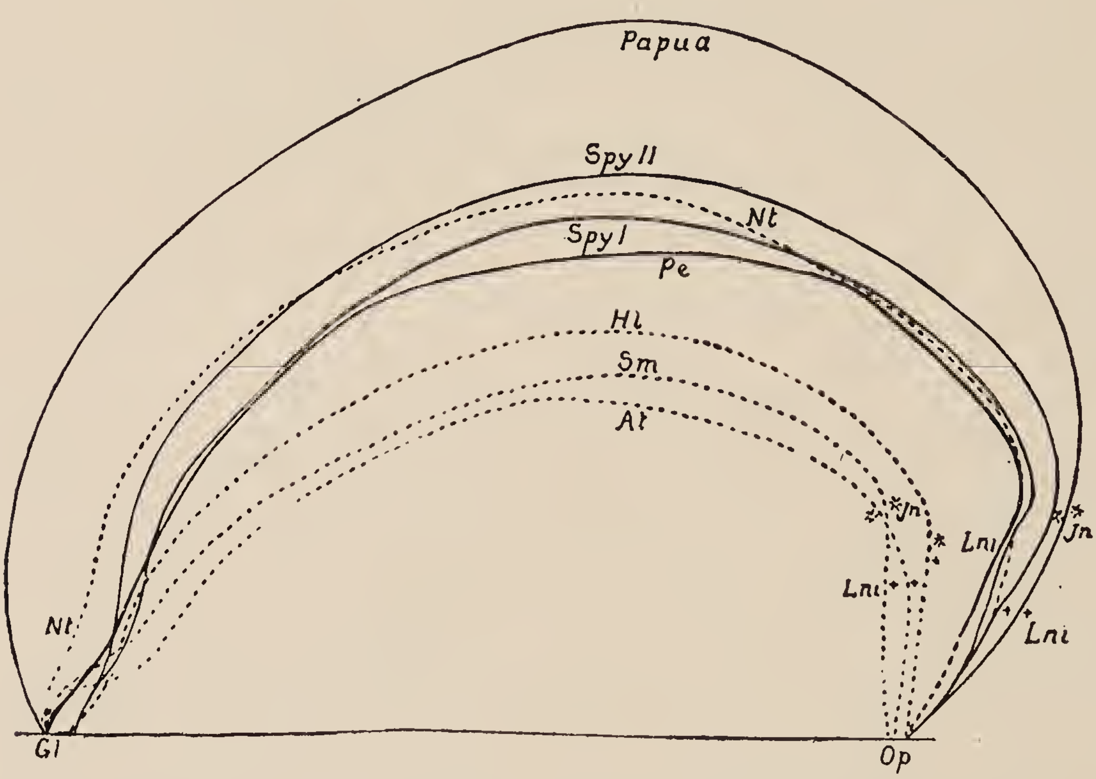

FIG. 93.—Profile outline of the Skull of Pithecanthropus (*Pe*), compared with those of a Papuan, the men of Spy, the Neander, thal man (*Nt*), Hylobates leuciscus (*Hl*), Semnopithecus maurus (*Sm*), and Anthropopithecus troglodytes (*At*).

of *Pithecanthropus erectus*. The femur denotes that it had an upright gait" (Woodward).

"The oldest human skeletons of which the geological age can be determined with certainty are two from the cavern of Spy, near Namur, in Belgium. These were found in association with remains of the mammoth and other Pleistocene mammals beneath a layer of stalagmite which had

never been disturbed. They are essentially human in every respect. They represent a race small but powerfully built. The forehead is low, the supra-orbital ridges are very prominent, and the chin is remarkably retreating. The leg cannot have been quite upright in walking. This type is known as the *Neanderthal race*, other similar fragments having been found in 1857 in a cavern in the Neanderthal between Düsseldorf and Ebberfeld, Germany "—(Woodward).

Fig. 93 shows the comparison of the skulls of these low races and some apes.

I am well aware that the series of animals shown is scanty and imperfect, but to present them all to the eye would require not fifty prints, but five thousand. I hope, however, that some great lessons have been made clear. We can at least form some idea of the enormous ages prior to the existence of man. In all the rocks up to the Quaternary we find no trace of human beings. The struggle and murder of millions of years raged without any help from man.

In order to learn clearly the lesson from the various animals we have seen, we require to take them in detail; but, as this is not possible, we will close with examples that sustain the doctrine of evolution in an unmistakeable manner.

Fig. 94 is a fresh-water mollusc of the Tertiary period. The series is to be read from the top, beginning on the left side. This remarkable series has been found in the lake basins of Slavonia. "Before the series was completed, some six or eight of the then disconnected forms were known and described as distinct species; but as soon as the connecting forms were found—showing progressive modification from the older to the newer beds—the

whole were included as varieties of one species"—(Romanes, 1–18). So that, as Romanes points out, organic forms are recognised as species only when intermediate forms are absent.

In this series there is a wide difference between

FIG. 94.—A complete series of Paludina.

the first and the last, but the difference between any two of them is so small as to be scarcely seen.

Fig. 95 shows the fact in a still more marked way. It represents four series of planorbis, another fresh-water mollusc of the Tertiary period. They are found near the village of Steinheim, in

Würtemberg, in an ancient lake-basin. The lake has long ago dried up, but its deposits are extraordinarily rich in fossil shells. It is a remarkable case in favour of the doctrine of evolution, which

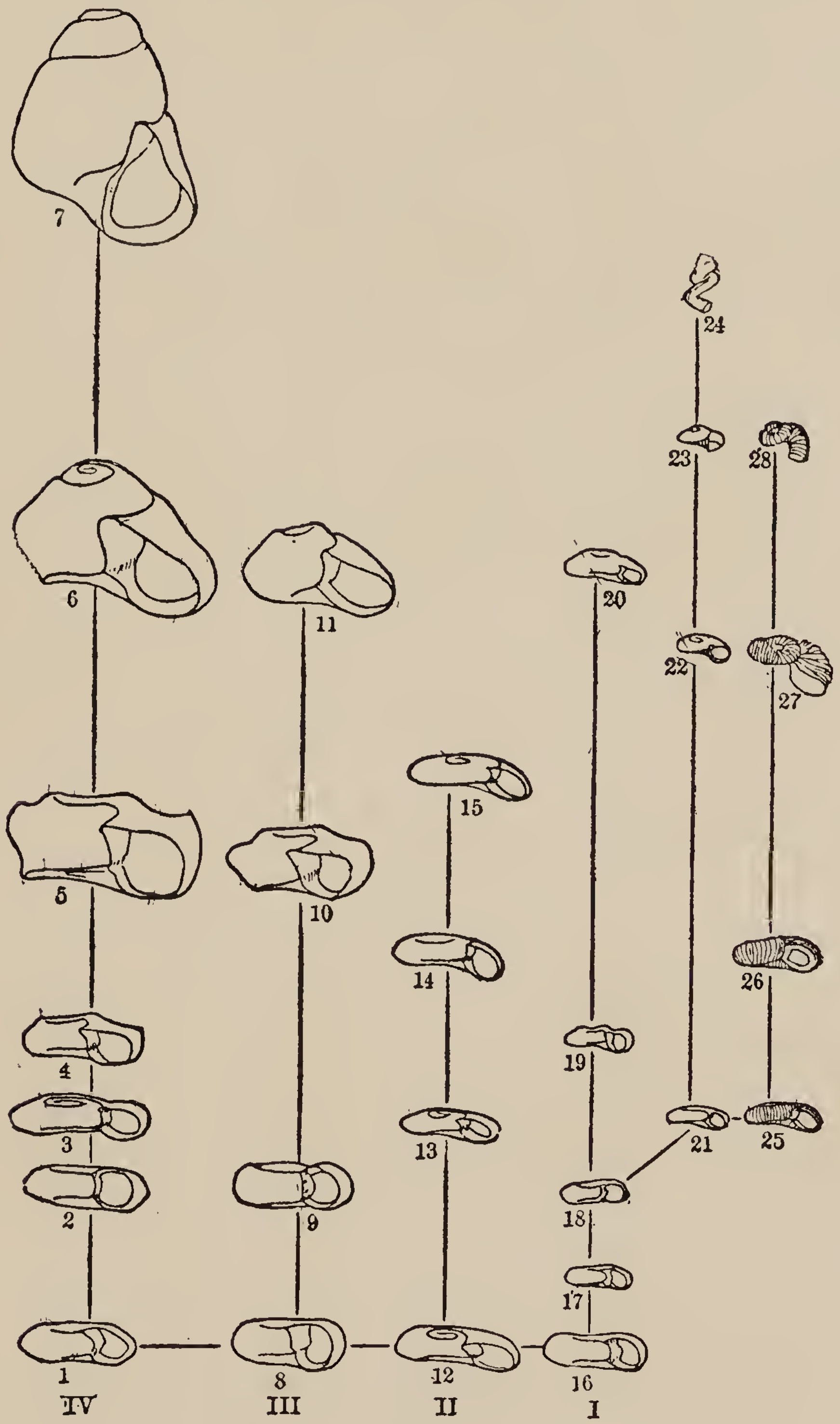

FIG. 95 —Series of Planorbis. (After *Hyatt.*)

teaches that new forms have been derived by small changes from older forms. I will quote the authoritative summary of the facts : " As the deposits seem

to have been continuous for ages, and the fossil shells very abundant, this seemed to be an excellent opportunity to test the theory of derivation. With this end in view they were exhaustively studied by Hilgendorf in 1866, and by Hyatt in 1880. In passing from the lowest to the highest strata, the species change greatly and many times, the extreme forms being so different that, were it not for the intermediate forms, they would be called not only different species, but different genera.

"And yet the gradations are so insensible that the whole series is nothing less than a demonstration of origin of species by derivation and modifications. This plate (Fig. 95) of successive forms from Professor Hyatt shows this better than any words. It will be observed that, commencing with four slight varieties, one at the bottom of each main column—probably only sexually isolated varieties—of one species, each series shows a gradual transformation as we go upward in the strata—*i.e.*, onward in time. Series 1, on the right, branches into three sub-series, in two of which the change of form is extreme. Series 4, on the left, is remarkable for great increase in size as well as change in form. In this plate we have given only selected stages, but in the fuller plates, and still more in the shells themselves, the subtlest gradations are found."

Now, words would only weaken this picture. If you fix your attention on No. 7 and No. 28, no one would suspect that these forms could have been derived from a common ancestor ; yet without a shadow of doubt they were.

From the last two figures some idea may be formed of what will be done to demonstrate evolution when thousands more series have been collected.

The great gaps which still exist are being filled up, and the evolutionist watches the process in calm assurance, for every discovery furnishes more abundant proof of the truth of his doctrines, and no series of animals has been discovered which tends to throw doubt on evolution.

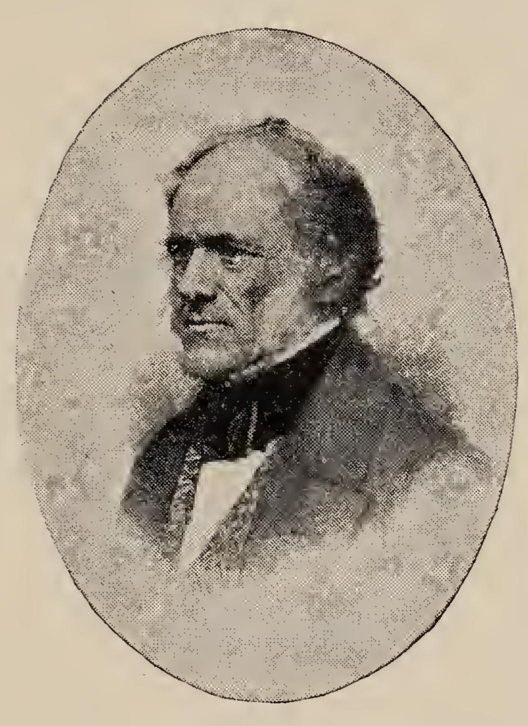

FIG. 96.—Sir Charles Lyell. Born 1797; died 1875.

Sir Charles Lyell was perhaps the most eminent geologist alive when Charles Darwin brought out his book, *The Origin of Species*. In a most important manner Lyell had prepared the way for Darwin's greater work, because he had shown in his *Principles of Geology* that there were none of those breaks which are called catastrophes. In fact, Lyell had killed the catastrophe-error; still, he was not able at first to accept Darwin's explanation of the origin of species. He was now sixty-two years of age, but he continued his studies, and when he brought out the tenth edition of the *Principles of Geology*, in 1867, he proclaimed that he had accepted evolution as true.

Such testimony from such a man, after eight

years of cautious inquiry at his ripe age, produced a marked effect, partly because Wilberforce, the Bishop of Oxford, had called upon Lyell to crush Darwin!

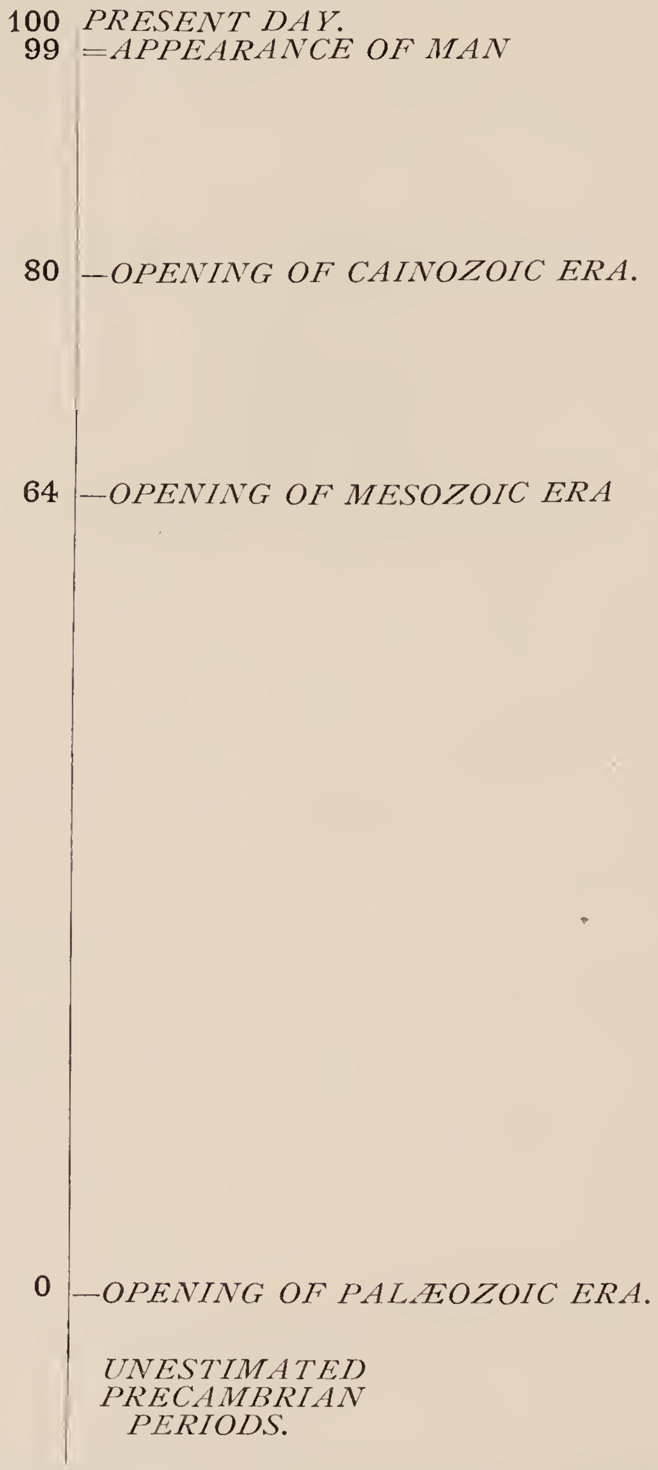

FIG. 97.—A Column of the History of Life on the Earth. (After *Professor Cole.*)

It may give some hope to life if we close by contrasting the age of man with that of other animals.

We leave out all the rocks earlier than the stratified rocks.

If we begin our annals at the base of the Cambrian rocks, with a time-point which we will call 0, and divide a column representing time from then till now into 100 divisions, like degrees in a thermometer, then we arrive at a figure approximately like Fig. 97, with the following results :—

I. The *Primary* rocks extended from 0 to 64 degrees of our scale. This is called the Palæozoic, or Old-life era.

II. The *Secondary* rocks terminated at 80 degrees. This period is called the Mesozoic or Middle-life era.

III. The *Tertiary* rocks extend over 19 degrees. This period is called the Cainozoic or New-life era.

IV. The *Quaternary* rocks occupy the last degree of our column. This period is called the Post-Tertiary or Recent era. The oldest remains of man are found at 99 degrees of our time scale, or one unit only from its summit, while human "history," in the ordinary sense, even that of the Chaldeans and the Chinese, can only be represented by a minute fraction of a degree—(Cole, p. 241).

Well may Professor Cole say: "Here we are met, then, by the most remarkable and inspiring feature in the whole annals of the earth. Man, with all his pride of life and reason, is still, as it were, only upon the threshold of his career......and we may look forward with confidence to the work which man, as a race, may yet achieve."

Chapter IV.

ZOOLOGY (TO MAMMALS)

We must not begin to consider evolution by first inventing false notions, and then say, with an air of wisdom, that they are not true!

It is not true that all things evolve in a straight line to something better; many forms scarcely evolve at all, and several forms go back instead of going forward. To have evolution there must be a favourable adaptation to a favourable environment.

It is not true that every form of high plant or animal has come through *every* plant or animal *inferior* to it. To find the relationship we must go back to ancestors, and not across to half-cousins. Man has not evolved from any of the living monkeys or apes. If you say that two brothers are related and of the same family, you do not mean that one was born of the other, but that each had the same parents. Again we say half-cousins are related, though they may differ widely in form and size, though one can sing and the other cannot. Oak trees do not come from rose trees, but, if you could trace them far enough back, you would find some tree or shrub that gave rise to the ancestors of each. Some animals have developed on the main line, but many have developed on side lines. Birds evolved on a side line, and, though both mammals and birds come from reptiles, yet mammals do not come through birds.

If a skilled man were taken into a room full of fruits and vegetables, he would be able to sort all the vegetables into one heap and all the fruit into another, even though vegetables and fruit may look like one another, or are similar in colour, in odour, in taste.

Bearing these things in mind, let us look at the animal world, as we find it in fossils and in living forms, and we shall learn that they are all one large family of different relationships.

We will begin with one of the lowest forms of living things.

The amœba (Fig. 98) is found in water. It is so small that you could not see it without a magnifying glass. It has no organs at all — no limbs, no mouth. It is always changing its form, whence its name. It is one cell, and when it becomes too large it divides in two and there are two amœbæ. This little speck of jelly-like matter is as simple a form of living thing as we can imagine any animal to be. And we have to work up from this simple form to all the wonders of animal life and beauty.

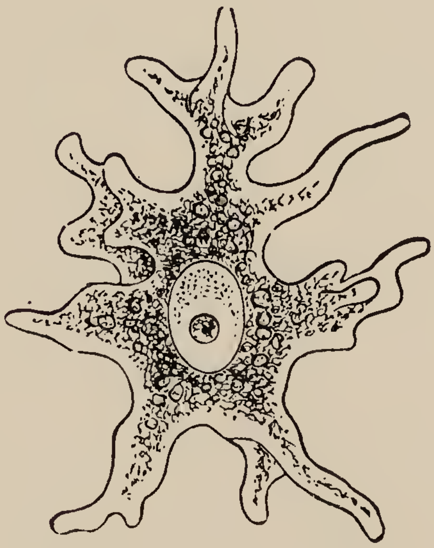
FIG. 98.—The Amœba.

The next step in evolution was that the cells, instead of dividing off, divided but clung together till there were thousands of forms of animals in the water. These are the many-celled animals. This formation by cohesion is, perhaps, the most marvellous step in evolution. The ultimate cause of this is not yet known.

The very small animals in Fig. 99 have been greatly magnified, and they show clearly how cells,

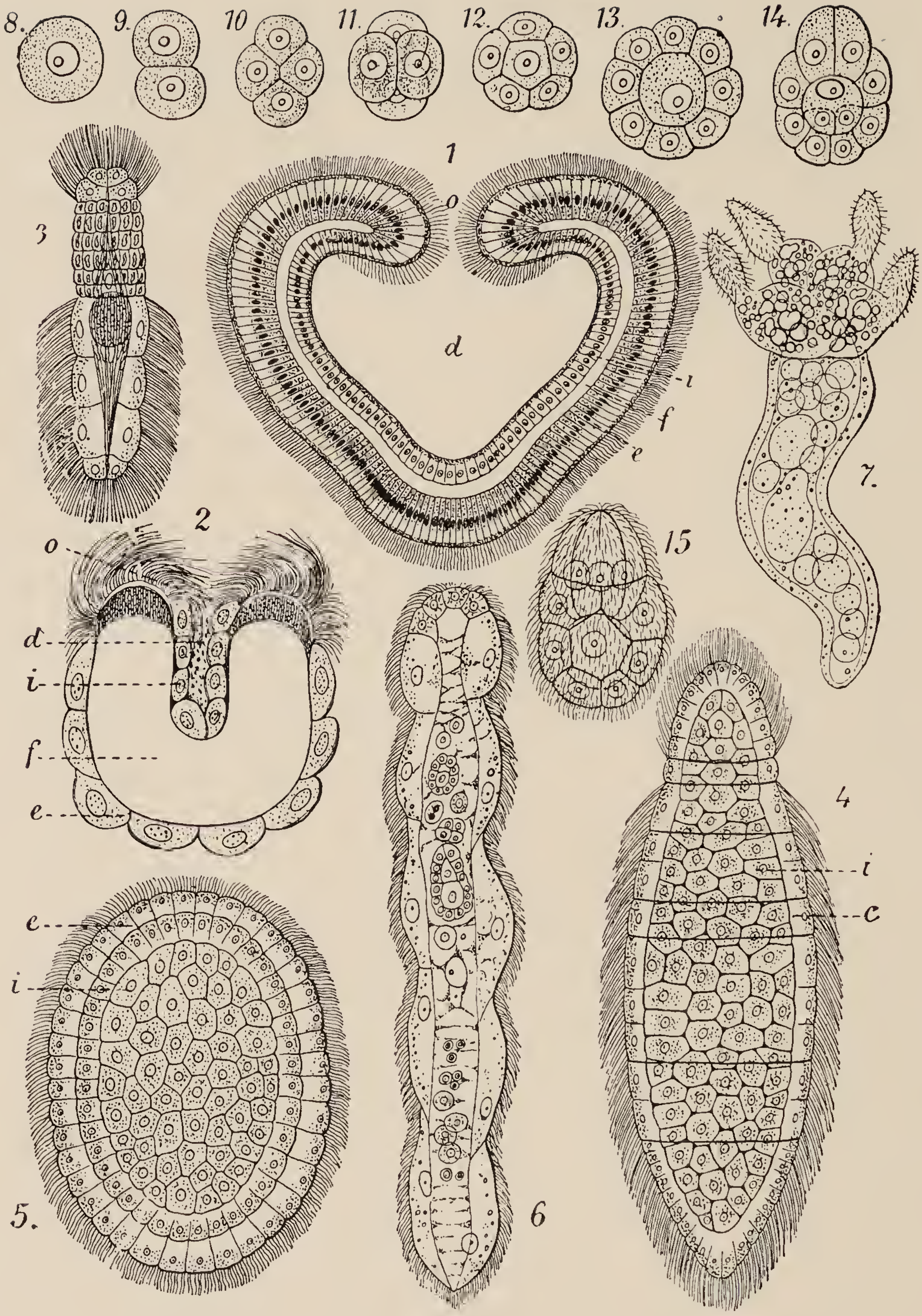

FIG. 99.—Modern Gastræads. Fig. 1, Pemmatodiscus gastrulaceus *(Monticelli)*, in longitudinal section. Fig. 2, Kunstleria gruvel *(Delage)*, in longitudinal section. (From *Kunstler* and *Gruvel.* Figs. 3–5, Rhopalura Giardi *(Julin)*: Fig. 3, male; Fig. 4, female; Fig. 5, planula; Fig. 6, Dicyema macrocephala *(Van Beneden)*. Figs. 7–15, Conocyema polymorpha *(Van Beneden)*: Fig. 7, the mature gastræad; Figs. 8–15, its gastrulation—*d* primitive gut, *o* primitive mouth, *e* ectoderm, *i* entoderm, *f* gelatinous plate between *e* and *i* (supporting plate, blastocœl).

after a single cell has divided, remain attached to each other, and so form a many-celled animal.

If you look at the figure marked 7, which is the full-grown animal, you can trace its growth all along the top line, from the single cell 8 to 15. One of the most marvellous facts known to man is that all animals (including man) grow in this same way.

All animals that have no bones, or internal skeleton, are known as invertebrates—*i.e.*, having no backbone. Invertebrates are divided into many families—worms, snails, flies, etc. Some of them soon acquired a digestive system, and small nerves, and feeble limbs ; and most of them went off on side lines.

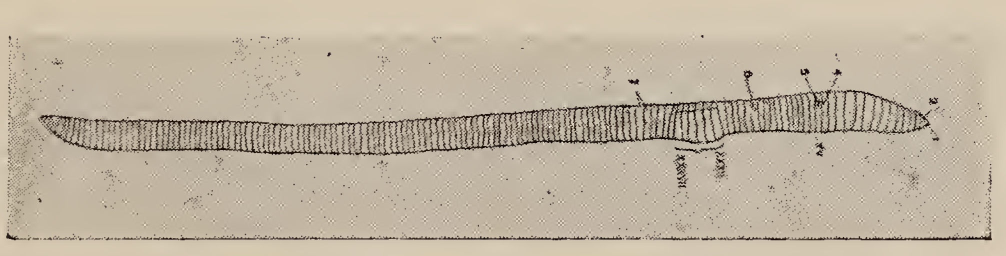

FIG. 100.—The common Earth-worm.

We are chiefly concerned with the worm-like class, for in these animals was developed a tube inside the outer tube—a second marvellous step. We call them hollow-bodied (Cœlomata). As the inner tube grew longer than the outer—probably because it was sheltered, and got more nourishment—the inner tube had to bend on itself. This went on for thousands of years, so that all the higher animals had intestines folded and folded one over the other.

The earth-worm is a land animal in which we find a well-marked hollow body and distinct blood system. It has a mouth at one end and a vent at the other. Still there are no bones. It is one of the invertebrates. We have now to look for the

origin of the back-bone. This took place in animals that live in the water.

The acorn-worm lives in the sea, burrowing in the mud. This animal is the most primitive member lying at the bottom of the very large class of back-boned animals, called on this account the vertebrates. One thing which unites all the vertebrate class is the structure called the *notochord*—

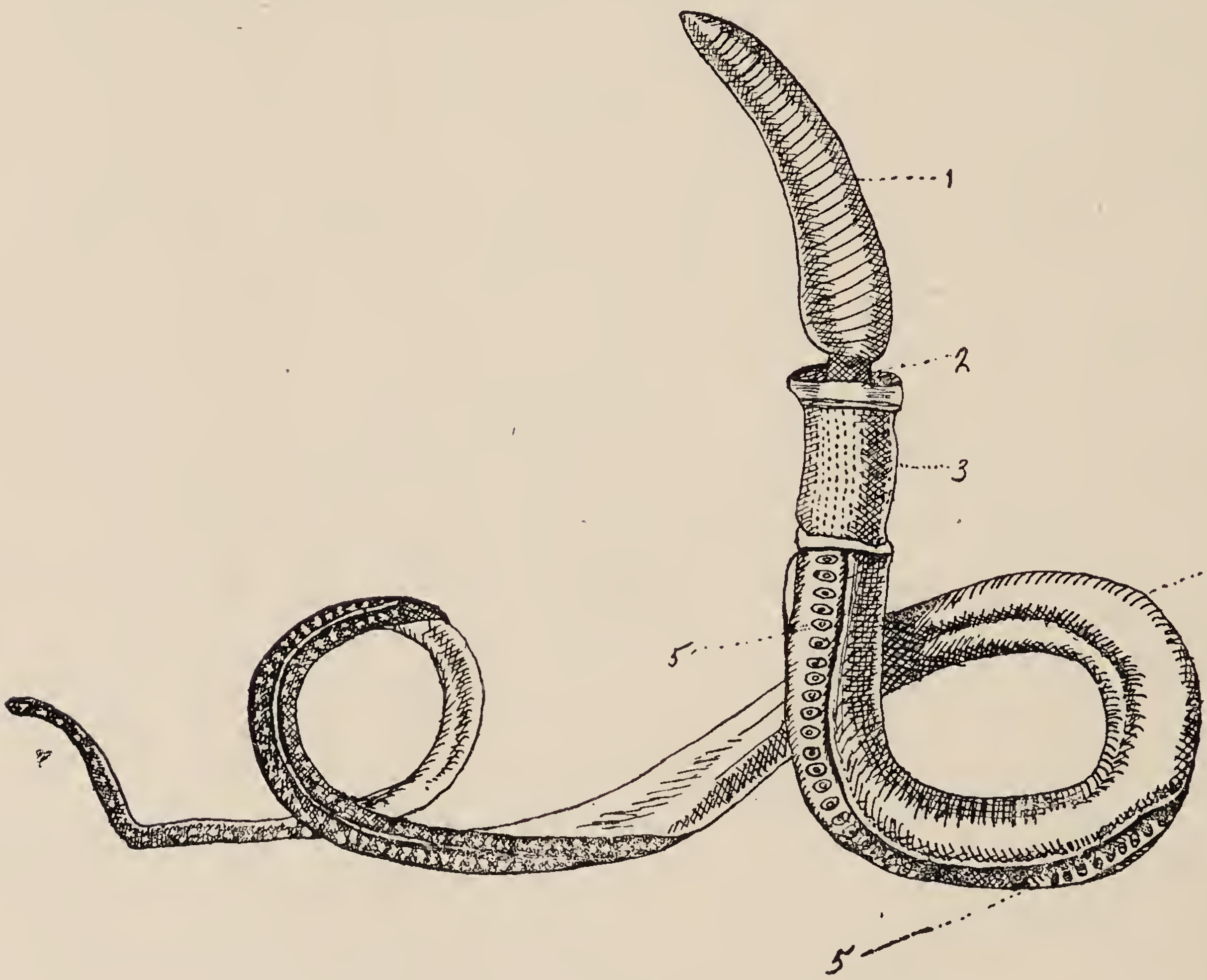

FIG. 101.—The Acorn-worm (Balanoglossus).

i.e., the chord of the back; it is a soft, thin string of jelly-like matter running along the back. A second feature of vertebrates is gill-slit openings in the front part of the inner tube (the alimentary canal), through which the animals breathe. These openings become gills. A third feature of vertebrates is the presence of a nervous system which takes the form of a strip of sensitive skin along the back. This usually becomes rolled into a tube, and

forms the *spinal cord* or nerve canal. These three marks will determine whether an animal is a vertebrate or not.

In Fig. 101 you can see the gill-slits marked 5. The collar is marked 2, and in this is found a very short notochord, which projects into the large proboscis marked 1. Also, in this collar, is found a short nerve-tube. Consequently we seem entitled to place this marvellous worm at the bottom of the vertebrate class. There are several species of acorn-worm.

The second member at the bottom of this class is the sea-squirt.

This form (Fig. 102) is a full-grown specimen, fixed to some support at the bottom, so that the animal does not move. These animals are called the Tunicata or Ascidians. The full-grown animal shows scarcely any trace of its relationship to vertebrates.

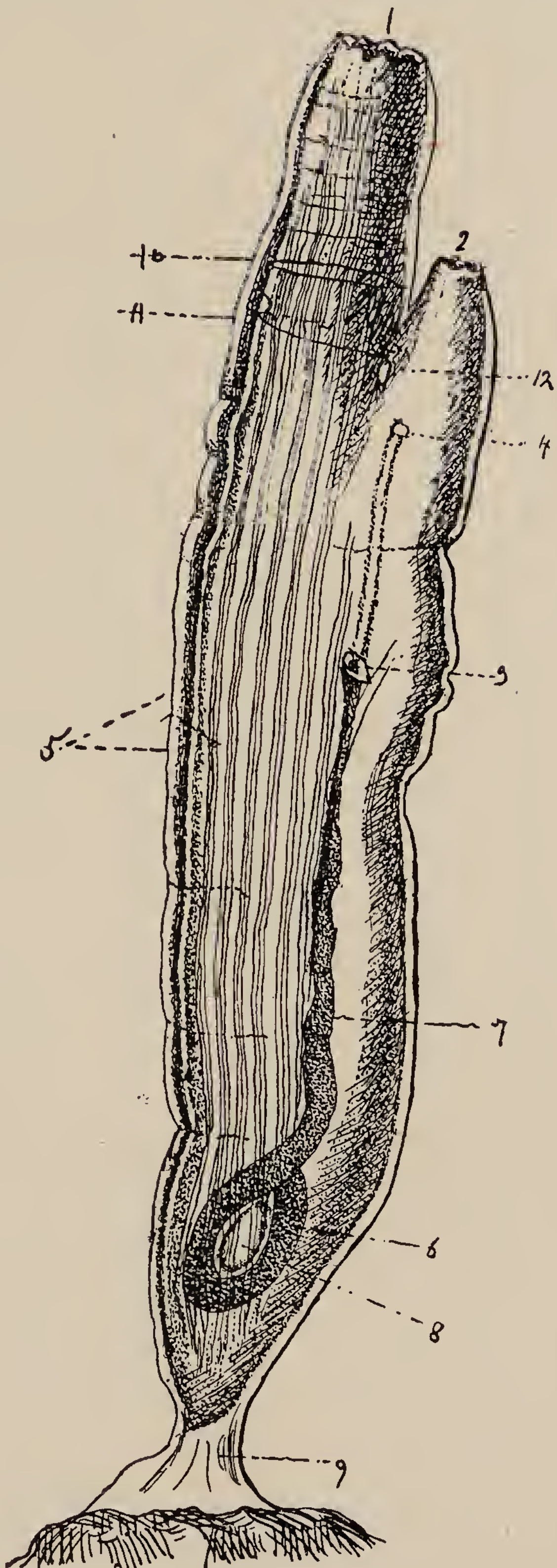

FIG. 102.—The Sea-squirt. 1, mouth; 2, atrial orifice; 3, anus; 4, genital pore; 5, muscles; 6, stomach; 7, intestines; 8, reproductive organs; 9, stalk attached to rock; 10, tentacular ring; 11, peripharyngeal ring; 12, brain.

In Fig. 103 the tadpole of the frog

and the tadpole of the sea-squirt or Ascidian are so much alike as to fill us with wonder, and you may see the faint notochord in each of them.

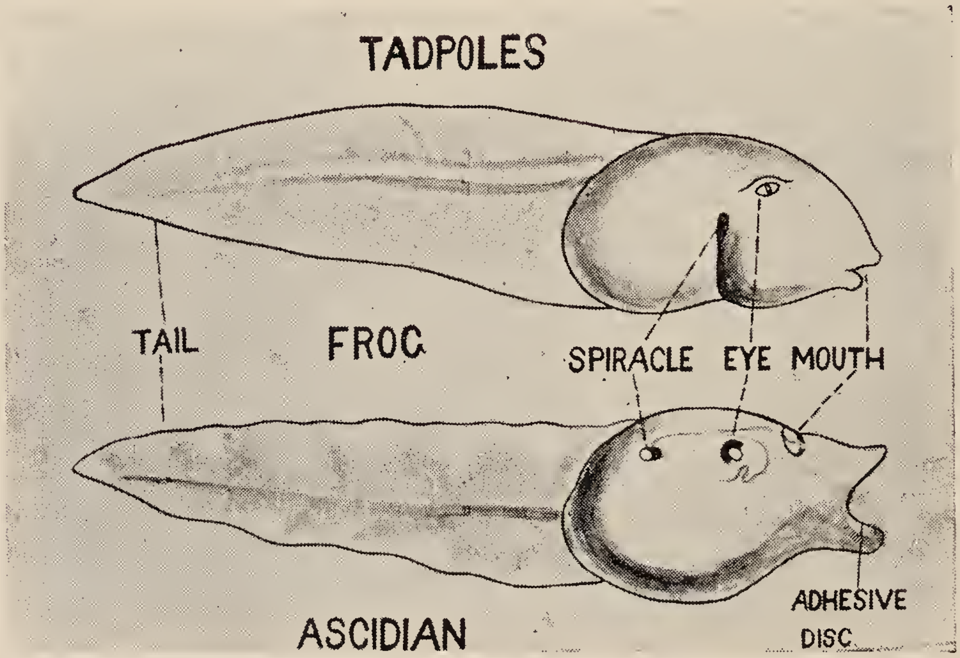

FIG. 103.—The Tadpole of the Frog, and beneath it the Tadpole of the Sea-squirt or Ascidian.

In Fig. 104 the notochord is the faint, short line running from the tail, but not the whole length of the body. You see above it the black nerve-chord swelling out in front. This enlargement is the

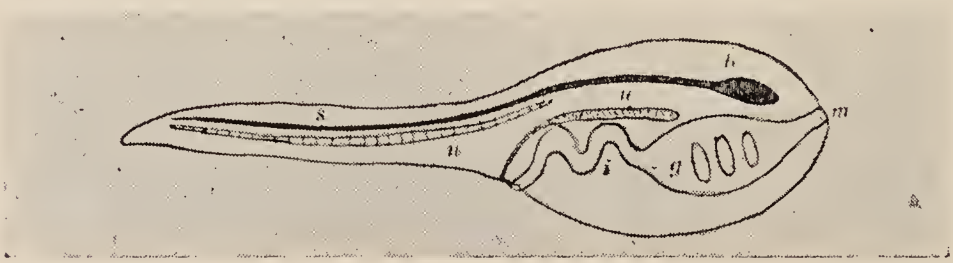

FIG. 104.—The Tadpole Ascidian.

forerunner of the brain of the higher vertebrates. As this tadpole grows it absorbs its tail.

The third remarkable animal at the bottom of the vertebrates is the amphioxus.

The name Amphioxus means sharp at both ends.

It is also called the Lancelet. This most marvellous animal is found in the sand of shallow seas. It is nearly transparent, and in Fig. 105 you see the notochord running along the whole length of the body. The Lancelet is from one to two inches long. It is very remarkable that here, for the first time, we meet with a shape very common among vertebrates, but almost absolutely unknown elsewhere. You observe that there is no head proper.

The importance of the notochord in helping us to know vertebrates can hardly be exaggerated.

These three animals—the acorn-worm, the sea-squirt, and the amphioxus—are probably only surviving representatives of many such; and, though they may not be the

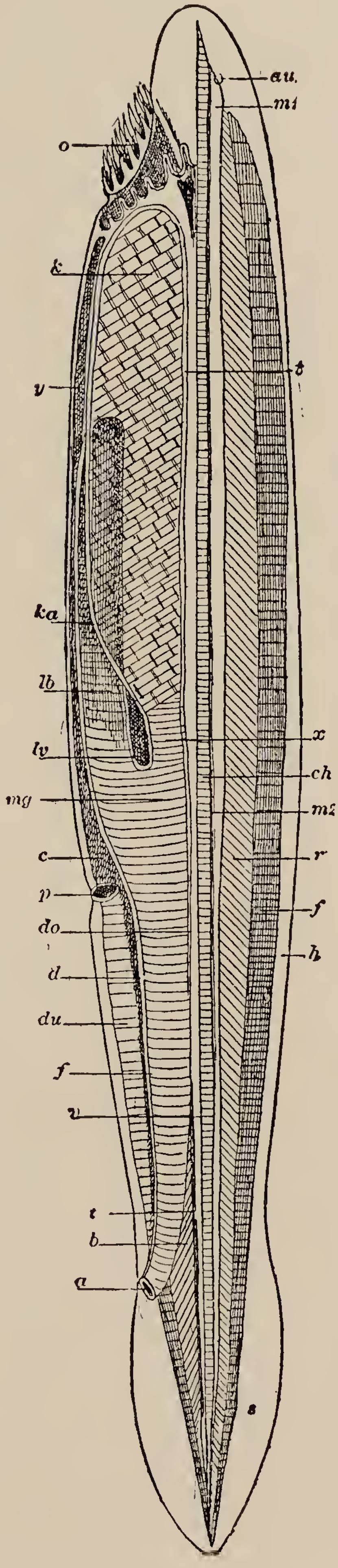

FIG. 105.—The Amphioxus Lanceolatus. (After *Haeckel.*) *a*, anus; *au*, eye; *b*, ventral muscles; *c*, body cavity; *ch*, notochord; *d*, intestine; *do* and *du*, dorsal and ventral walls of the intestine; *f*, fin seam; *h*, skin; *k*, gills; *ka*, gill artery; *lb*, liver; *lv*, liver vein; *m1*, brain bladder; *m2*, spinal marrow; *mg*, stomach; *o*, mouth; *p* ventral pore; *r*, dorsal muscle; *s*, tail fin; *t*, aorta; *v*, intestinal vein; *x*, boundary between gill-intestine and stomach intestine; *y*, hypobranchial groove.

direct ancestors of fish, yet we are able to see how fish may have arisen.

All the land vertebrates apparently came through the fish group. Fishes are the lowest group of true vertebrates.

FIG. 106.—Vertebræ.

We see in Fig. 106 the vertebræ, or bones of the back, as they form a complete back-bone. We can now clearly understand what we mean by vertebræ which make up the back-bone. All animals having a back-bone are called vertebrates.

We will take a rapid view of several fishes, that we may have some idea of the vast variety of these animals, from which came our own ancestors.

In Fig. 107 are low forms of fish, the lampreys, with a head scarcely marked from the body.

These are often called the Cyclostomata — round-mouthed fishes. You may see in the upper right-hand form (Fig. 108) the round sucker by which the animal attaches itself to objects. In this it resembles the amphioxus. These fishes have no jaws, and the nose is represented by a single sac. Altogether, it is a low, simple fish. In fact, so simple that the round-mouthed fishes have a division to themselves, marked off from all the other fish which have jaws.

The class Pisces (fishes) are not characterised by their gills, but by their fins. "It is believed that

the paired fins are derived from the division of two originally continuous lateral flaps."

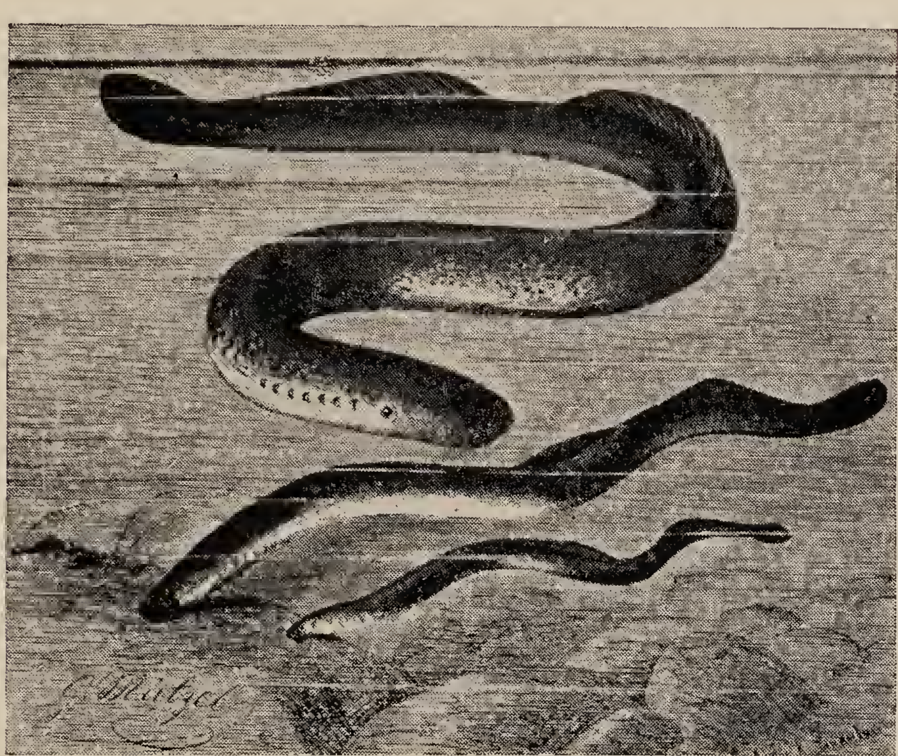

FIG. 107.—A Group of Lampreys.

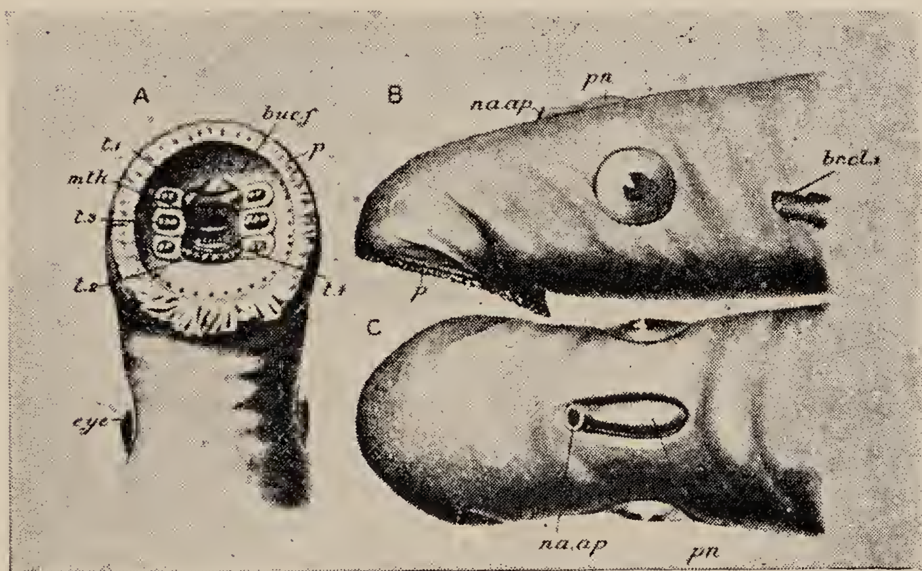

FIG. 108.—Head of a Lamprey.

Fishes are divided into four orders:—

1. Elasmobranchii.
2. Holocephali.
3. Dipnoi.
4. Teleostomi.

"These orders can also be distinguished in the case of fossil fish, though the differences become less marked as we recede backward in time; and many indications point to the conclusion that the common ancestors of the four orders would, if we could examine them, be classed as Elasmobranchii. Hence the Elasmobranchii may be termed the basal group of the Pisces, although the modern

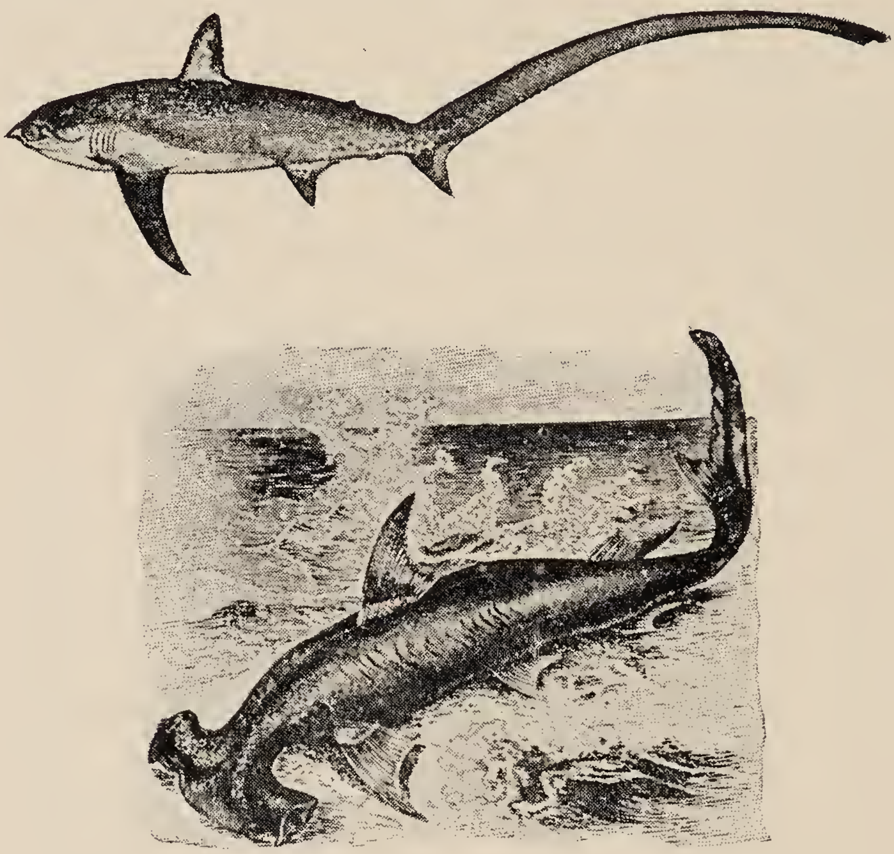

FIG. 109.—The Thresher Shark at the top, and the Hammer-headed Shark below.

Elasmobranchii, like all modern animals, are specialised in many respects" (Shipley and MacBride, 353).

Order 1, the Elasmobranchs, contains

Sharks (Fig. 109),
Dogfish (Fig. 110),
Skates and Rays (Fig. 111).

All this old family shows a low, undeveloped form, and, like the round-mouthed fishes we have

seen, these can scarcely be said to have any *bones*, as their skeleton consists chiefly of *cartilage*. Note how slowly and gradually the bony skeleton is evolved.

Order 2, the Holocephali, differs from the Elasmobranchs chiefly in the skeleton; in the viscera they resemble them very closely.

This order, once numerous, now is represented by three genera closely allied, of which the best known is the chimera or rabbit fish (Fig. 112).

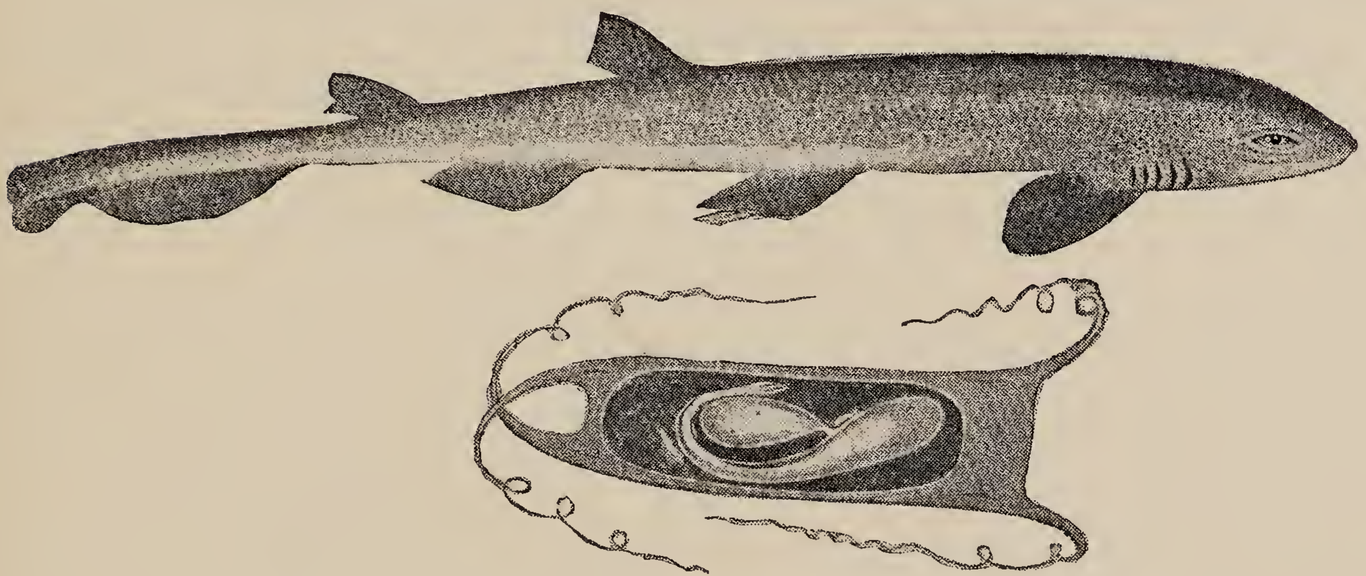

FIG. 110.—A Dog-fish.

Order 3, the Dipnoi, or double breathers, sometimes called lung-fish, has only three species :—

The Burnett salmon (Ceratodus) (Fig. 113),

The Mud-fish (Protopterus) (Fig. 113),

And the Lepidosiren (Fig. 114).

But the most interesting of all to us is the group called Dipnoi (Figs. 113, 114), *double-breathing fish*. They breathe not only in the water by means of gills like ordinary fishes, but they have a lung or *lungs for breathing the air*, and in consequence the circulation of the blood differs from that of ordinary fishes.

Their only living representatives are the Burnett

salmon (Ceratodus) of Queensland, which has one lung, and the mud-fishes of certain South African and South American rivers which have two lungs.

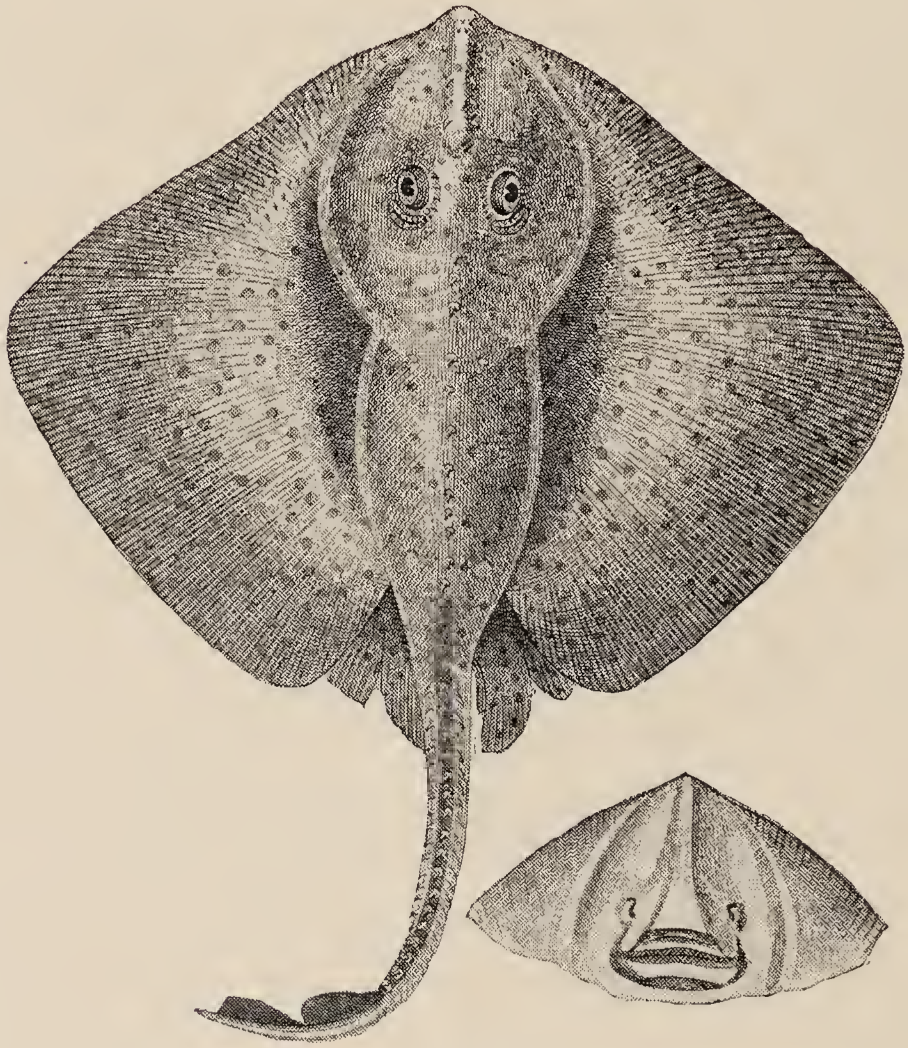

FIG. 111.—Skates and Rays.

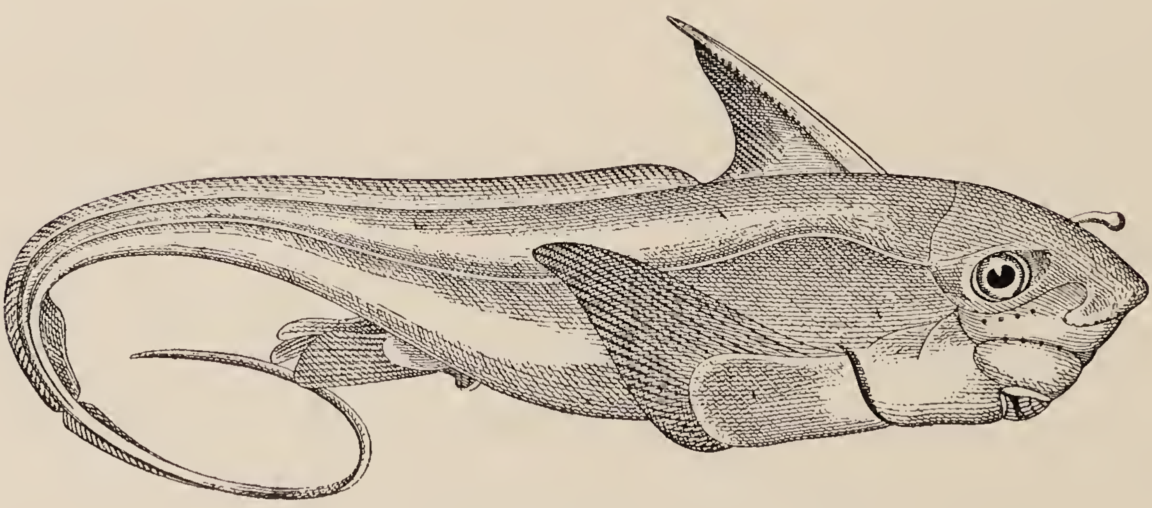

FIG. 112.—Chimera or Rabbit Fish.

All land animals probably came through this group!

Order 4, the Teleostomi, is divided into two sub-orders :—

a. The Crossopterygii (the fringe-finned).—There are only two living genera of this sub-order, the

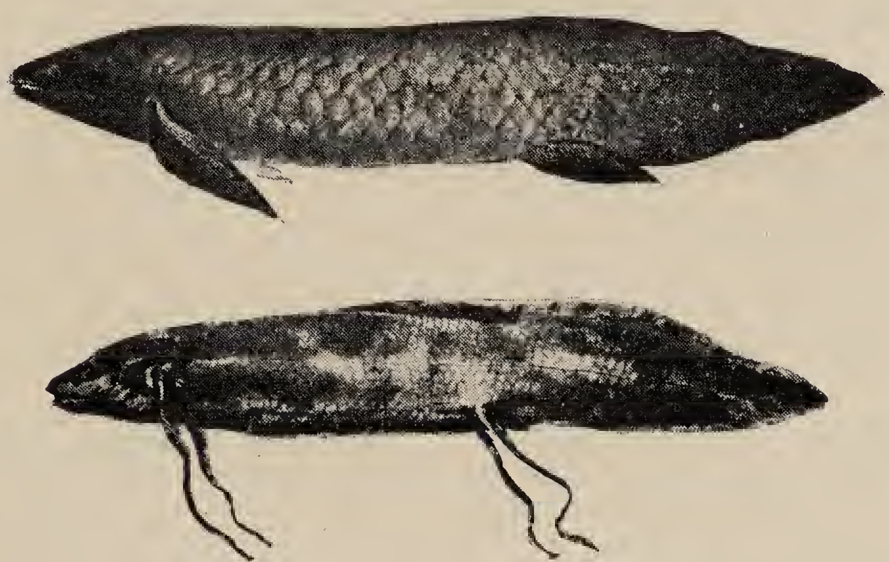

FIG. 113.—The Burnett Salmon above, the Mud-fish (Protopterus) beneath.

FIG. 114.—The Lepidosiren.

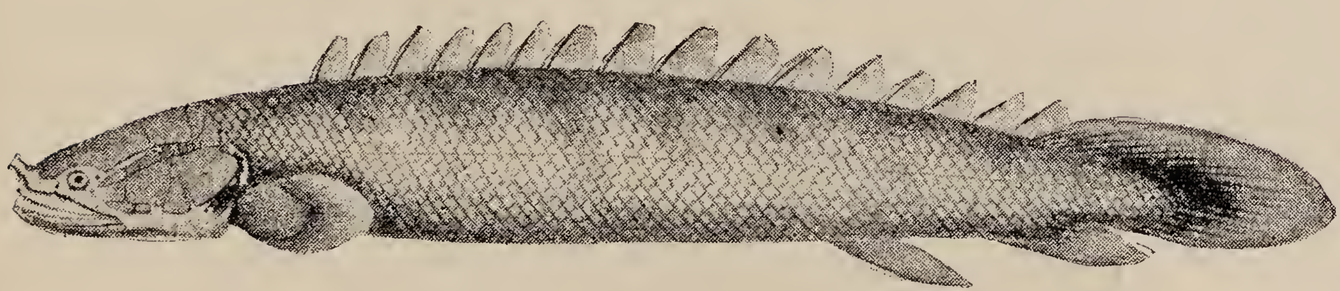

FIG. 115.—The Polypterus.

Polypterus (Fig. 115) and the Calamoichthys, which inhabit the rivers of Africa. "The Crossopterygii are probably in some respects more nearly related to the ancestors of Amphibia than are modern Dipnoi. This view is strengthened by the

fact that the air-bladder is occasionally used as a lung. The young have one large external gill attached to the operculum. As in the Dipnoi, the mouth is terminal" (Shipley and MacBride, 378).

b. The Actinopterygii.—This sub-order is divided into two great divisions, the Ganoids and the Teleosts. The common sturgeon (Acipenser, Fig. 116) is the best known of the Ganoids, and it, with three other small groups, is comprised in the Ganoids. All the other numerous families are Teleostii, which include most of our best-known fishes, as salmon, pike, herring, sole, perch. There are perhaps ten thousand species in this division.

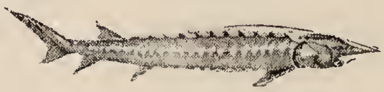

FIG. 116.—The Sturgeon.

I will show you a few specimens not so well known, that you may have some idea of the strange variety of these creatures.

FIG. 117.—The Lump-fish above, and the Blenny below.

This blenny is very peculiar, for most fishes lay eggs, but the blenny brings forth its young alive.

FIG. 118.—Sea-horses and Pipe-fish.

Sea-horses and pipe-fish are most marvellous, for their young are developed from small eggs, in a pouch on the belly of the *male*.

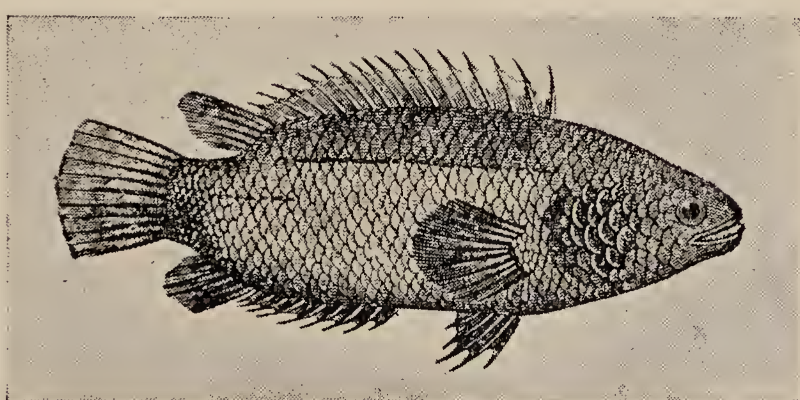

FIG. 119.—The climbing Perch.

The climbing perch (Figs. 119 and 120) has climbed so long that it has nearly become a land-animal, and would drown if you were to compel it to stay in water.

Fig. 121 shows a fish the name of which means: one who can see all round. (He would perhaps do for a Prime Minister!) You observe he can climb, and from his position you get some idea how the fins of fish may have developed into limbs.

Fig. 122 shows the flying fish. Its large pectoral fins sustain it in long flying leaps through the air. The only source of its motion is from the use of the tail as it leaves the water—it may keep up 200 yards.

Fig. 120.—Perch climbing the tree trunk.

These wonderful links help us to understand how land animals were evolved from fishes. You will note that our vertebrates are all water animals so far, and we want to "land our fish" and watch his development there.

The early land animals were very fish-like. I wonder how many people would care to classify the objects in Fig. 123 at first sight.

The animals in Fig. 123 look as if they represented only one group, but they are chosen from three distinct orders. The bottom one is an electric eel, and is a fish. The middle one is an amphibian (Cæcilia lumbricoidea), and belongs to the same order as frogs and toads.

The top one is a reptile (the Amphisbæna). It has the rare qualification of being able to walk either end first.

The extraordinary variety shown in the class of fishes is most striking, and, when once we understand even a little of the law of natural selection,

FIG. 121.—The curious goggle-eyed creature, Periophthalmus, of the Indian and Pacific Oceans.

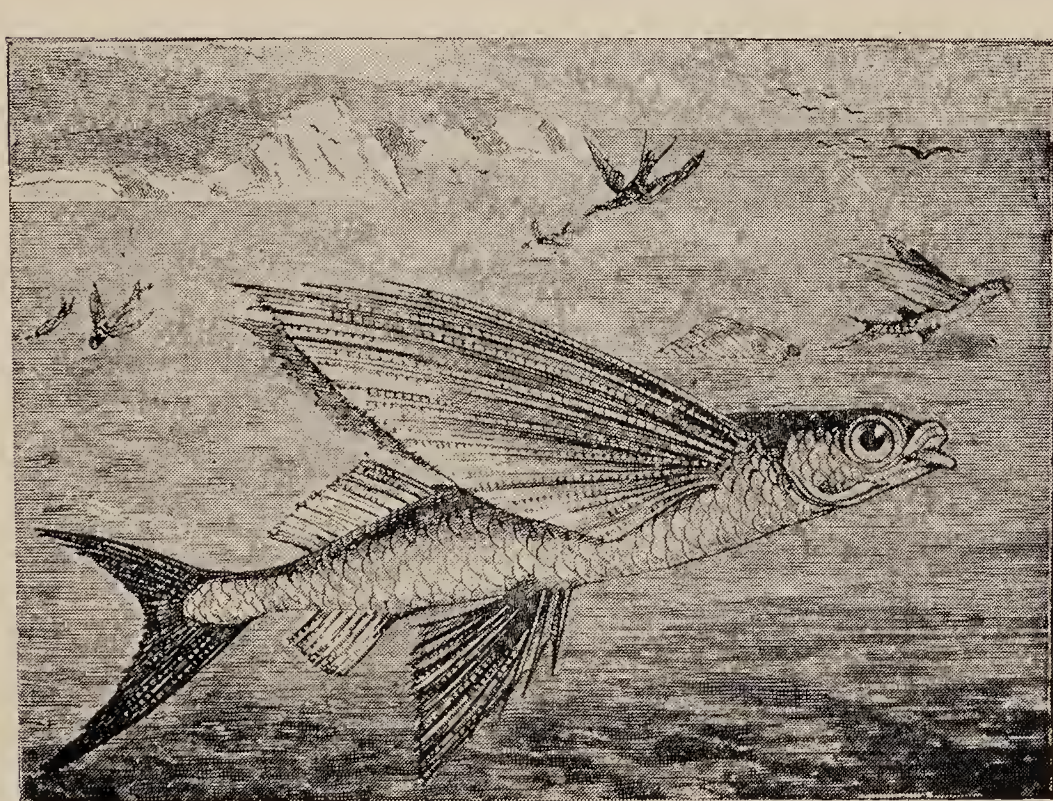

FIG. 122.—The Flying-fish.

working on the variations offered, we shall not wonder that out of such innumerable varieties of species at least one variety took to living on land.

But this was an enormous advance, and must have taken place very slowly. Only by a vast series of small changes was it possible for the structure of a water-breathing animal to become so altered that the animal could live on land and breathe the air.

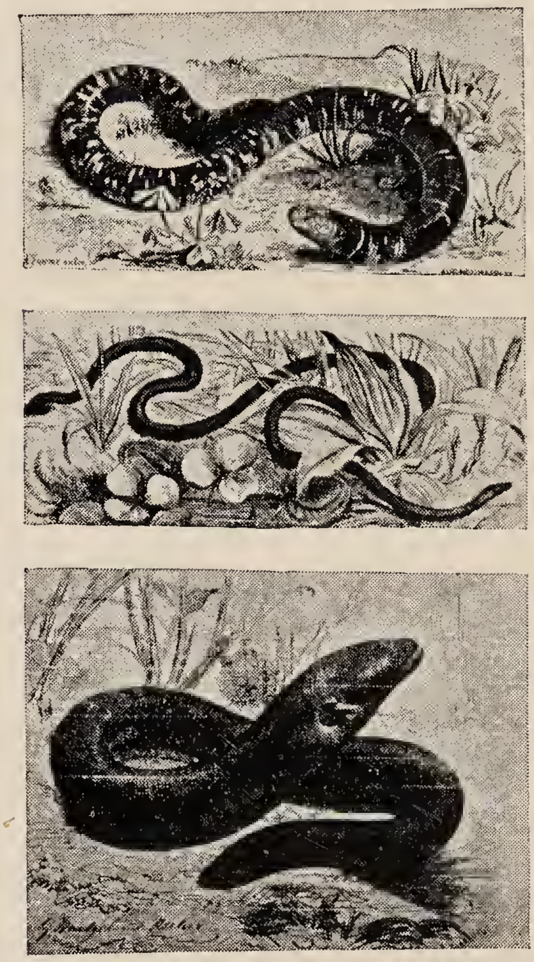

FIG. 123.—Three distinct Orders.

The wonderful connecting-links between the two extremes of fishes on one hand and land animals on the other are called *Amphibians*. The word means simply a double life—water and land. Amphibians are the class of animals which can live both in water and on land at some stage of their existence. As far as living species are concerned, they are the least numerous of the vertebrates, and the class contains about a thousand species. This is a small number compared with the 2,700 mammals, 3,500 reptiles, over 8,000 fishes, and almost 10,000 birds—(Gadow).

The poor amphibians have had their day. It is a long time since they flourished and divided the reign of the world, as far as vertebrates were concerned, between themselves and the fishes.

There is no doubt that amphibians spring from fish-like ancestors, and that in turn they have given rise to reptiles, so that we see they hold a position between the two, and are really a connecting link. Perhaps, within vertebrates, the greatest gulf lies between fishes and amphibians—between water animals with internal gills and fins and land animals, four-footed, with lungs and fingers and toes.

But we know that some fish have one lung and some two (see Fig. 113), and that some others can leave the water for a while (see Figs. 120, 121, 122). We must look for the origin of amphibians from these groups of fishes—the dipnoi and the crossopterygii.

The siren, or mud-eel, is an amphibian without hind limbs and possessing remarkable gills. It seems far nearer the fishes than a toad is.

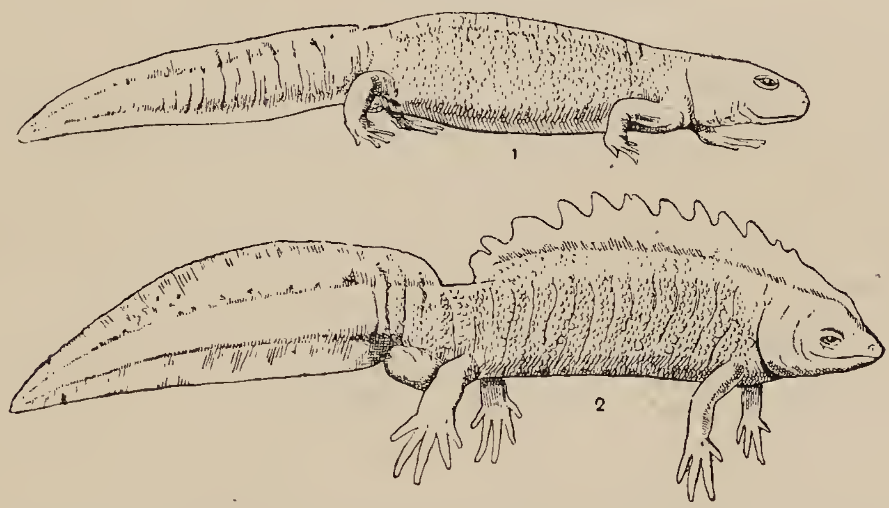

FIG. 124.—Triton Cristatus, the Warty Eft. 1, female; 2, male at breeding season, with the frills well developed.

This newt, or eft, is found in ponds and ditches, and, though a modern animal, yet it resembles the dipnoi in its arrangement for breathing, and it may help us to form some notion of the appearance of the earlier amphibians.

The eggs of the frog are on the left (Fig. 125). These grow larger till you may see the tiny tadpole in one, and then many free-swimming tadpoles all together under a leaf. First the hind legs appear, then the fore legs, and it absorbs its own tail, and

FIG. 125.—The Growth of the Frog. 1. Tadpoles just hatched. 2 and 2a show external gills. 3 to 8 show the order in which the frog developes.

thus far finds its own food. (This is a simple way of solving tariff reform!)

At one stage it has gills, a large tail, no limbs, and dies if left on land. It is, to all intents and purposes, a fish. But at length nearly every trace

of fish has disappeared. We have to bear in mind that the frog is a recent and specialised amphibian.

We come next to reptiles. The word "reptile" means crawling or creeping thing. They have a scaly skin, and most of them very short legs. They include crocodiles, tortoises, lizards, and snakes. At one time the world must have been nearly full of them, as we can tell from the very numerous fossils which are found everywhere.

Before the higher animals came into existence amphibians and reptiles had the land to themselves, and they increased and multiplied to an amazing degree.

We are pretty certain of the group of reptiles which gave rise to mammals, but we do not know the group which gave rise to birds. It is easy to tell a reptile from an amphibian; but Dr. Gadow says "it is difficult to distinguish them as a class from the birds."

All reptiles can be divided into eleven subclasses, and Dr. Gadow says "there is not the slightest doubt that they are evolved from some branch of the stegocephali (the roof-headed amphibians); while, on the other hand, the reptiles, probably through some branch of the theromorpha, have given rise to the mammals; some other reptilian branch, at present unknown, has blossomed out into the birds"—(p. 278).

To us, therefore, reptiles are a very interesting class, for clearly, if all mammals came through reptiles, man also came through the same reptilian ancestors.

We must constantly refer to Figs. 73 and 74 for the roof-headed amphibians (stegocephali), and to Figs. 75, 76, 77 for the theromorpha.

We must always bear in mind that the vast majority of reptiles are extinct.

The first three great sub-classes are :—

I. Proreptilia.

II. Prosauria (containing orders, microsauri and prosauri).

III. Theromorpha (containing orders, pareiasauri, theriodontia, anomodontia, placodontia).

The remaining sub-classes do not concern our present inquiry, but the first three sub-classes, with their early low forms, are of the greatest interest to us in looking for the origin of mammals.

The sub-class I., proreptilia, contains two genera, eryops and cricotus, both found in the Permian formation of rocks in North America. They are called proreptilia, which really means before reptiles proper, to show that they are the lowest known reptiles, and that they probably link this class to the amphibia. In fact, for a time they were mistaken for amphibia, and classed with the roof-headed. In some points they resemble the roof-headed amphibians, and they are found side by side with them in the lower Permian rocks.

The sub-class II., the prosauria, which means before lizards proper, includes small newt-shaped, chiefly Permian, reptiles. These little creatures had five fingers and toes, but they stand almost as low as the first sub-class, and in many points resemble amphibians.

The most amazing thing about this sub-class is that there still exists a living specimen, the sole surviving member of this very early group.

There is only one species of him (sphenodon punctatus), and that is found in New Zealand, living there in the pride of antiquity. Try and realise what the ancestors of this beautiful creature

must have seen. They were surprised by the flight of the first bird; they looked in wonder on the first mammal; and a few centuries ago they stared in astonishment at an odd, *new* creature called—man!

Had the sphenodon family enjoyed the rare privilege of living under a British Government, which could have sent him to a workhouse school, he

FIG. 126.—Sphenodon Punctatus.

might have kept a diary, every page of which would have been worth its weight in tears!

He is the last living witness of those bygone ages, and, as we should expect, he is an ideally *generalised* type of reptile. Soon he will be unknown, for bush fires, wild pigs, dogs, cats, reptile-eating Maories, and the glories of civilisation have swept him away, except on some of the small uninhabited islands. He sleeps most

of the day. He lives on animals. He is said to be lazy in his movements. This may have had something to do with his living so long, for we know it is the *pace* that kills.

He needs a chapter to himself.

The sphenodon is a primitive reptile, and not a lizard.

The third sub-class, the theromorpha, which name means mammal-shaped, is still more interesting to us, for out of this sub-class arose the mammals.

All the reptiles of this sub-class are extinct. The earliest known occur in the lower red sandstone of

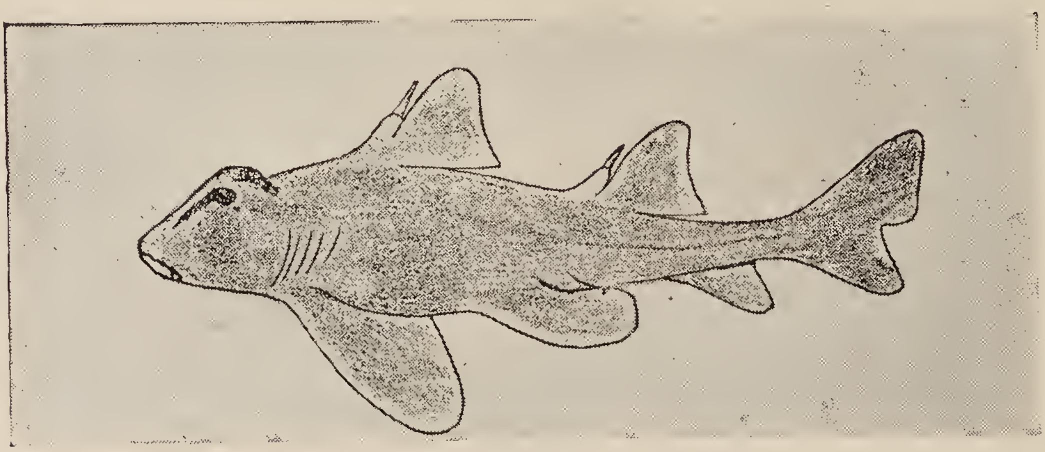

FIG. 127.—The Ichthyosaurus.

Thuringia and Bohemia, and in the middle Permian in Russia.

So extensive were they that there are four distinct orders already known, some specimens of which we have already seen (Figs. 75, 76, 77).

The great variety of fossil reptiles requires a book to give any complete idea of their number.

We may perhaps realise from looking at the ichthyosaurus that there is not much doubt about the fish ancestors of some reptiles. Still, under the skin of the paddle, the limb nearest his head, he has a beautiful hand with six fingers, but he has

worn gloves a long time. The race is extinct now, and he will glove no more!

Some of these animals were only three inches long, and some a hundred feet, and weighed many tons each.

In looking at living reptiles we must remember they are rather *recent* forms. They are an unlovely crew, and yet, in many countries, several of them have been worshipped as gods. Perhaps this was a form of "ancestor worship" in another sense.

From ancient reptiles, now extinct and buried, have arisen, on two entirely different lines, both

FIG. 128.—Ramphorhyncus.

mammals and birds. Perhaps the mammals arose first. At any rate, it is clear that birds and mammals are two *distinct* groups. We will deal with birds first. They are of amazing interest as showing the marvels which may take place when the offspring of a common ancestor develop on separate lines for tens of thousands of years. Few people wonld see any connection at first sight between a snake and a bird. But if we look at some bird-like reptiles we may begin to see some likeness. Of course, before we can trace any like-

ness to reptiles we must strip them of their feathers. Reptiles are scaly animals, and, strange as it may sound, it is true, nevertheless, that feathers are

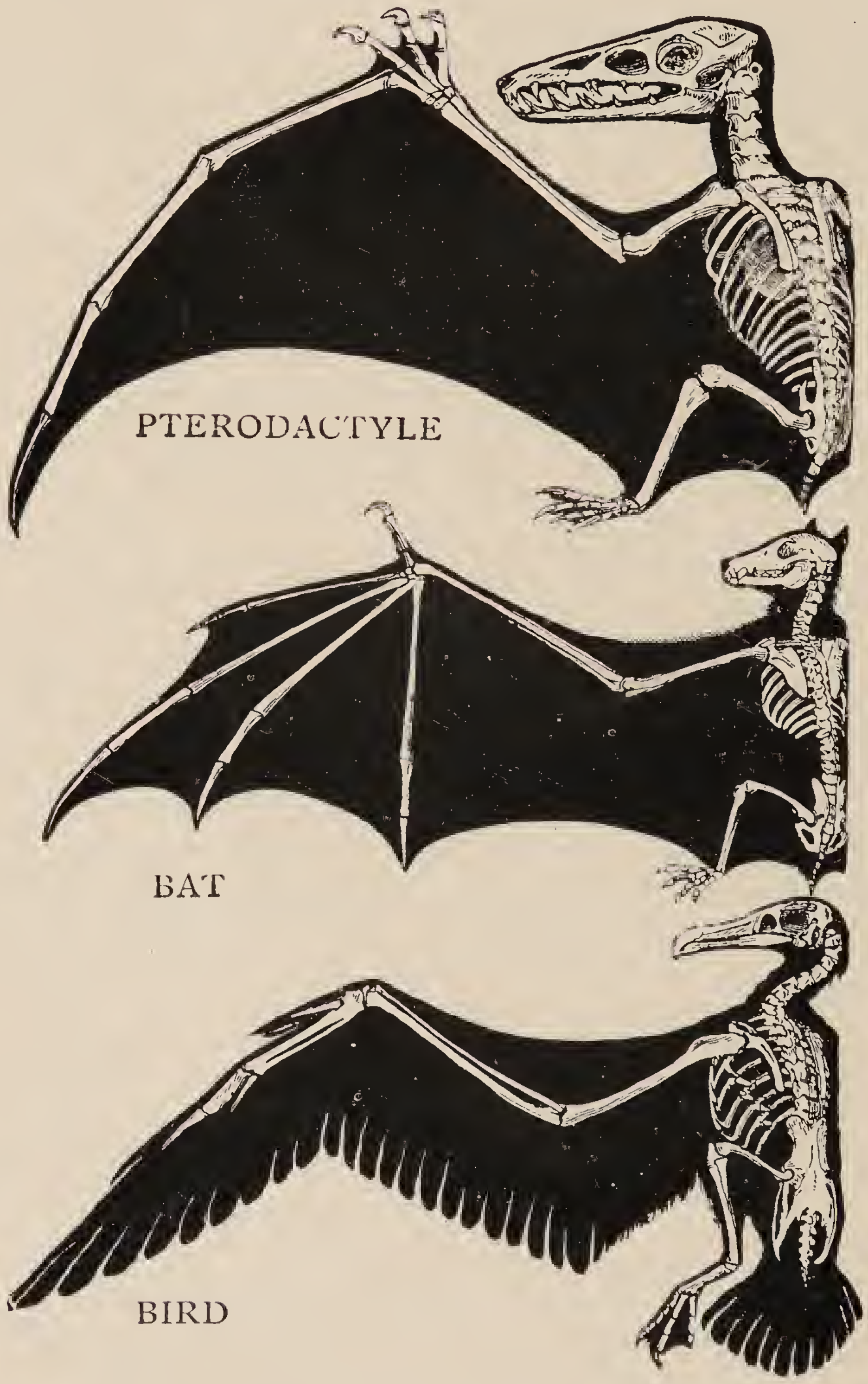

FIG. 129.—Wing of Reptile, Mammal, and Bird.

really scales, like those found on lizards, immensely developed, and with the edges frayed out. Like scales, the feathers are developments of the outer

or horny layer of skin. We will look at some reptiles which are bird-like.

FIG. 130.—The Archæopteryx.

The reptile (the rhamphorhyncus, Fig. 128) had wings of membrane. This has been found in Bavaria in the Jurassic rocks.

In Fig. 129 the one at the top is a pterodactyle——the wing-fingered *reptile*. You may observe that the finger is greatly prolonged to support the wing of membrane on its fore feet. The bones are, like those of a bird, hollow or filled with air. These were huge, winged, bat-like creatures; they also were found in the Jurassic rocks. The middle one is a mammal, the lowest is a bird.

Fig. 130 is undoubtedly "an old bird." It is called the archæopteryx—the ancient wing. This is the oldest of known birds, and comes from the same rocks as the preceding reptiles. It was rather smaller than a crow, and united some of the characters of reptiles with those of a true bird; for instance, it has a long, lizard-like tail, each vertebra of which bore a pair of quill feathers. The three wing fingers were all free, and each ended in a claw. It had four well-developed toes.

We may close our reference to birds by one example of a remarkable living bird, the apteryx or the kiwi of New Zealand (Fig. 131).

This bird has the merest rudiments of wings, and they are so hidden that they appear to be altogether wanting. The plumage is so delicate and peculiar that it seems more like hair than feathers. They are said to live in pairs, and to pass the day in holes in the ground and to come out at night.

They are the smallest birds of a very large family, to which the ostrich and the emu belong; and in historical times New Zealand had the largest specimen of this family, the moas (dinornis),

which had thigh bones larger and thicker than those of a horse.

As we are more interested in mammals than in birds, these few examples of birds must suffice to show that all nature is one, that the most unlike animals may come, by different lines, from the same ancestors. So when you see a cat which has

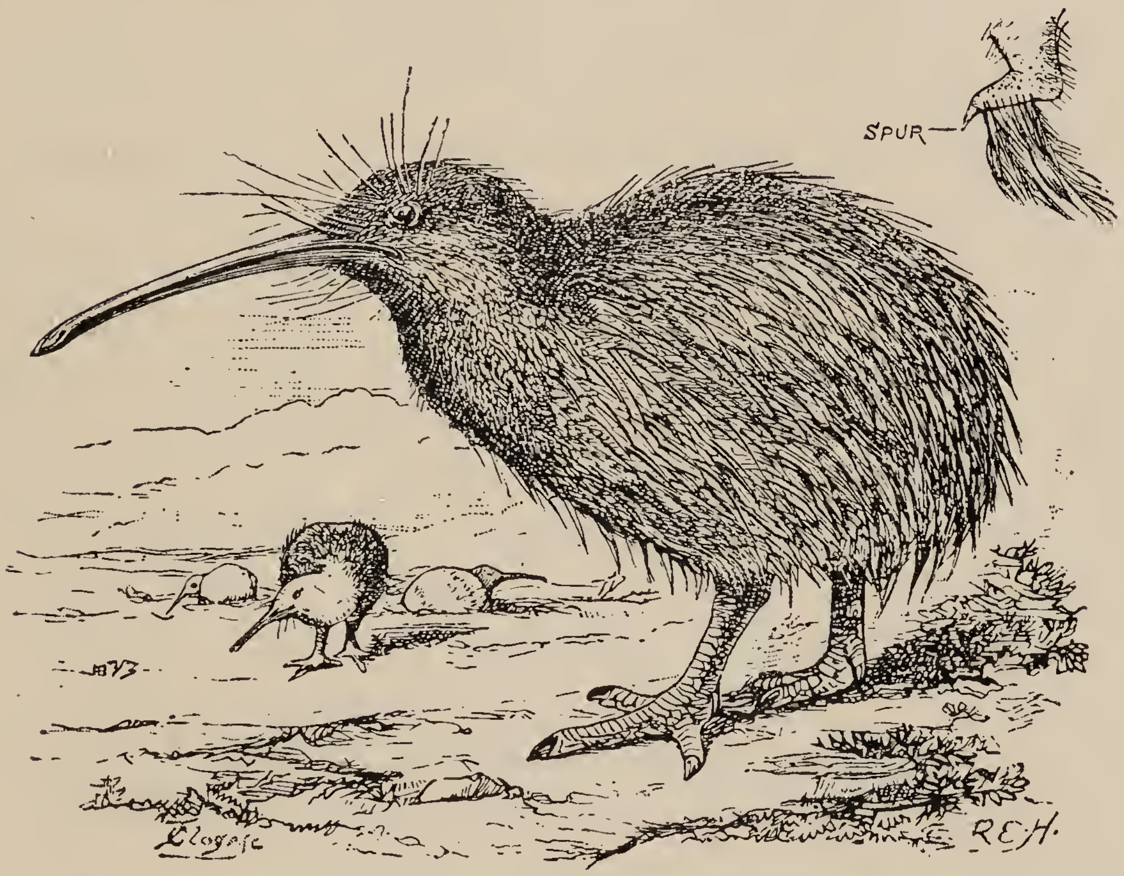

FIG. 131.—The Apteryx.

caught a sparrow, you may remember that both the cat and the sparrow have come through reptiles from the same group of roof-headed amphibians. You cannot *cross* from one side line to another, but if you trace every side line far enough back you will find they all meet in great centres. These centres we call groups of ancestors.

Chapter V.

MONKEYS AND MAN

In this chapter we trace the evolution of mammals. To us this is the most important group of all, for to this group we ourselves belong.

We shall never understand evolution unless we remember these three laws :—

(1) Many animals have developed on side lines, and, after this development, they are no longer of any concern to us when we are looking for the evolution of man. Birds are a good example of a side line which parted very early from the line of reptiles. Mammals and birds have no connection except this, that they came from two different groups of reptiles.

(2) When animals have so developed that they have become highly specialised and often of great size, further development does not come from them, but frequently they become extinct.

(3) The large animals can be shown, almost invariably, to have come from small, unspecialised ancestors.

Many of these early simple forms have become extinct, because, in the struggle for life, they were destroyed by the superior specialised animals. Yet, here and there, in the out-of-the-way corners of the earth, a few have survived, and by means of these and the fossil ancestors which are dug out of the rocks we are able to trace the evolution of many families of animals with remarkable clearness. If we bear these three laws in mind, perhaps we

shall not be so astonished at some of the wonders in the development of mammals.

Fig. 132 is a common form of mammal. All animals, the mothers of which suckle their young, are called mammals, from the Latin word *mammæ*, breasts. It matters not what is the form of an animal or where it lives, if it suckles its young, it must belong to this CLASS—MAMMALS or MAMMALIA. There are many other distinguishing marks, but this is sufficient.

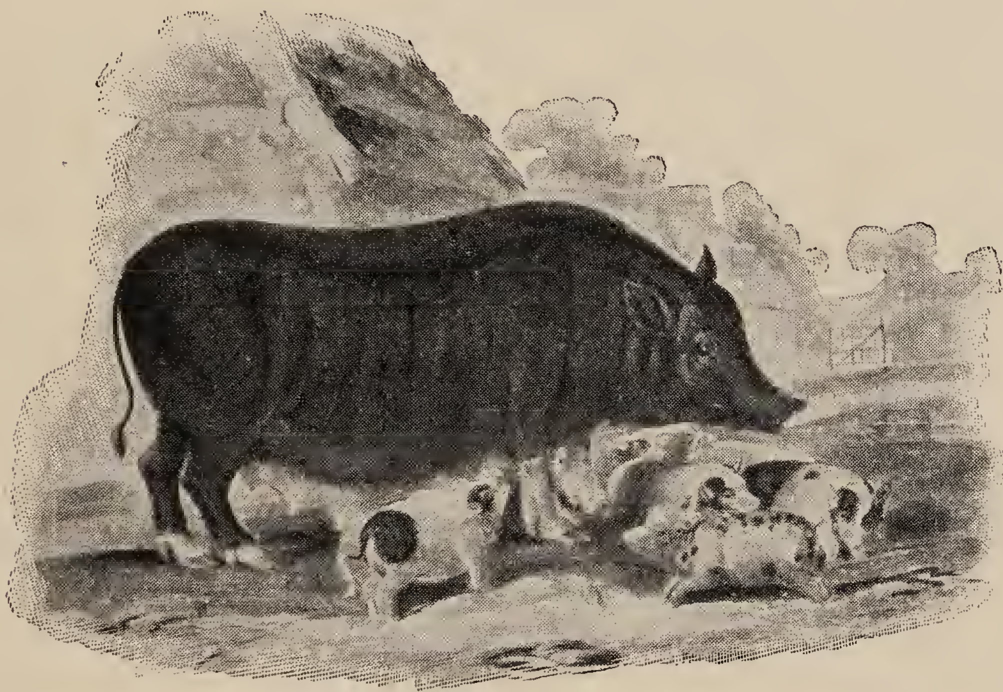

FIG. 132.—A Sow and her Young.

Viewed externally, FISH are distinguished by their fins, REPTILES by their dry, horny scales, BIRDS by their feathers, and MAMMALS by their hair. We must remember that feathers, scales, and hair are all growths of horny cells—being, in fact, modifications of the skin—and, in a general sense, are all alike, though their mode of growth is so different that one can never be mistaken for the other. Scales are still found, with hairs between, on armadillos, and practically all the fingers and toes of

mammals have either nails or claws, which are modifications of the scales of reptiles. The beautiful dappled markings on some horses are said to be due to the scales of the ancestors from which the horse is descended. So you can contemplate your finger-nails with greater reverence in future, for they show that you come of a "good old family"—the reptiles.

We must retrace our steps to this "good old family" of reptiles, and see how such very different animals as the cat, the cow, and man may have arisen.

Though birds may be traced back to reptiles not very unlike common lizards, mammals are derived from a type of reptiles which died out long ago, and left no living representatives; so mammals are, in all probability, an older group than birds.

We have seen that amphibians came from fish, that reptiles came from the extinct roof-headed amphibians, and that from a very ancient family of reptiles, called mammal-shaped (Theromorpha), the true mammals are descended.

We must bear in mind that, compared with these very ancient reptiles, all mammals are recent animals, though they may have been on the earth millions of years.

All mammals are divided into three classes:—

1. The primitive mammals (Prototheria).
2. The modified mammals (Metatheria).
3. The perfect mammals (Eutheria).

To understand the growth of mammals we must do as we do with all other things—we must begin with the simplest first.

Now it would puzzle anyone to imagine how the cow could have come from the lizard (Fig. 133). Here

note that nobody says the cow did come from the lizard. This figure is a fine example of that wise saying, "A problem wrongly stated is insoluble." What Evolution teaches is that all mammals came through a *group* of reptiles, not that one mammal came through one particular reptile. If we could grasp this, we should begin to understand what is meant by evolution. In all cases of ancestry we

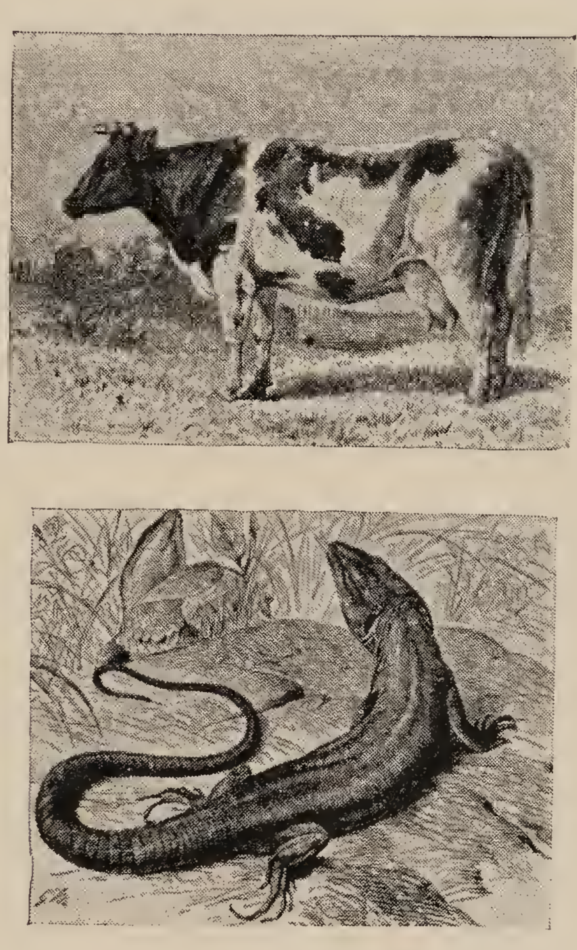

FIG. 133.—A Cow and a Lizard.

deal with *groups*, often large groups, and usually groups that have become extinct.

So, instead of beginning with a well-developed mammal, like a cow, we will take the duck-mole, or the duck-billed platypus (ornithorhynchus) (Fig. 134). This is, without doubt, one of the most interesting animals in the world. When it was first brought to this country it was believed to be a deliberate

fraud, much of the same kind as the Mermaids which used to be made by neatly stitching together the fore-part of a monkey and the tail of a salmon!

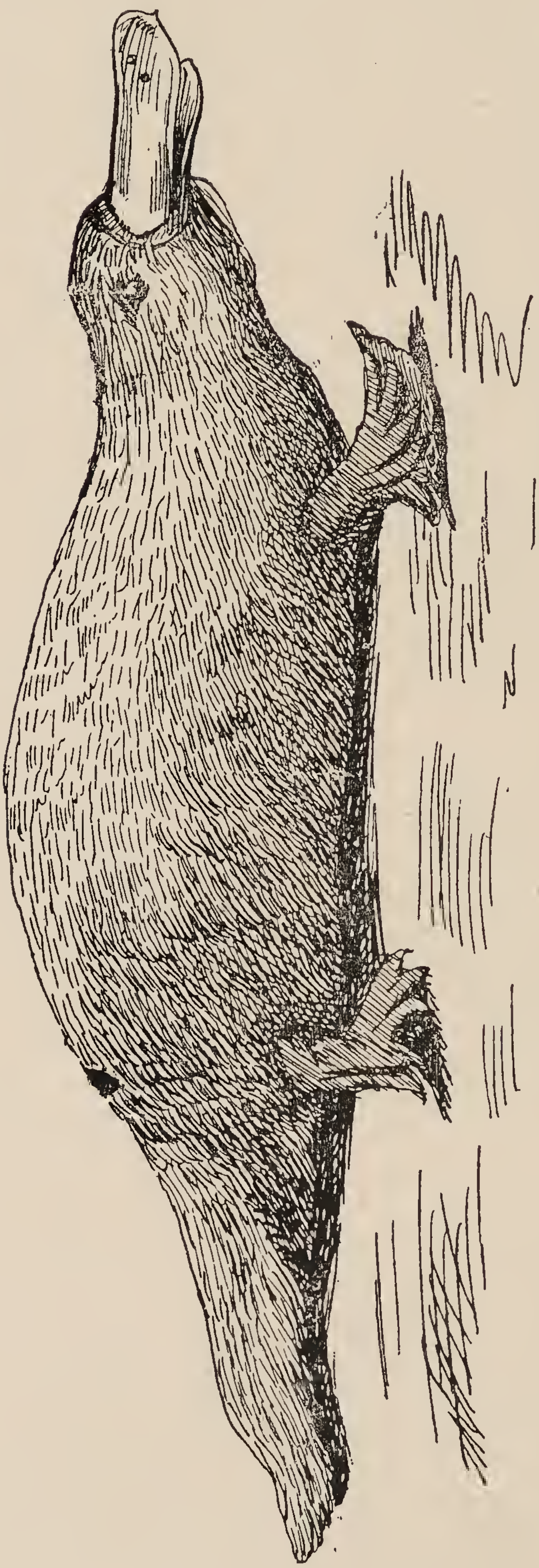

FIG. 134.—The Duck-mole.

The duck-mole is the only representative of one of the two families of primitive mammals. Its latest home was in Australia and Tasmania; now it is practically extinct. Fossil remains found in Australia indicate a smaller animal than the recent duck-mole.

The living duck-mole is covered with a dense fur of a blackish brown colour; the limbs are short and five-toed, the toes being webbed. The webbing on the front toes extends considerably beyond the tips of the claws, as in seals. The beak is broad and flat, and suggests that of a duck; it is not, however, covered with horn, but with a fine,

soft, sensitive, naked skin. The brain is smooth, and there is no *Corpus Callosum*, or band of nervous matter, uniting the two hemispheres of the brain, as in the higher mammals. It has real teeth for a considerable portion of its life, and they are only shed like milk teeth, after being worn down by friction with food and sand. These teeth show a general resemblance to the teeth of certain of the earliest of mammal-like reptiles found in fossils. This duck-mole is a water animal, and makes a burrow for itself in the bank of a stream. It lives chiefly on animal food—"grubs, worms, snails, and most of all on mussels."

The duck-moles lay large eggs like reptiles and birds. The eggs are covered with a firm shell, laid in a nest, and incubated by the mother. After they are hatched, the young receive milk from the mother. There is no teat for them to suck, but the fluid from the milk glands seems to soak into the hair, and thence is sucked by the young. Note this wonderful, simple beginning.

There are many other points which show the close connection of these animals with reptiles; but surely, from these given, anyone may see how closely the early ancestors of mammals must have been connected with the reptiles from which they sprang. This lowest living specimen of a mammal is very imperfect, and has so many characteristics of other animals that we may truly say that in the duck-mole we see mammals in the making.

We pass to the next group of mammals, the modified mammals. Fig. 135 shows us the rock wallaby, which is of the same sub-family as the kangaroos, and, in fact, they are so much alike that they are virtually the same.

There are many sub-families of these animals.

For the most part they are found in Australia, but some kinds are seen in the islands to the north of it. But (in the Mesozoic epoch), millions of years ago, they occurred in Europe and North America in very great numbers. One main sub-division is still found in South America. To deal with all the kinds of this division of animals would require a long chapter.

They are called marsupials, from *marsupium*, a pouch. In this pouch, as you see, they can carry their young. The most striking difference between the marsupials and the duck-mole family is that the marsupials do not lay eggs. The young are developed within the mother, and they are brought forth in such an imperfect condition that she takes them with the lips and puts them in her pouch, where they are placed upon the teat. These animals when born are small and nude, the young of a large kangaroo being about the size of the little finger. They are not only born imperfect fœtuses, but they are actual *larvæ*, for they have a larval organ in the shape of a special sucking mouth. They are quite unable to feed themselves, and the mother, by contracting her muscles, squeezes the milk gland and forces the milk down

FIG. 135.—The Rock Wallaby.

their throats, very much as the mother whale has to do.

In too many points to be named these animals are an advance upon the primitive mammals. They have developed a clavicle, or collar bone; they have teats; the hemispheres of the brain are furrowed, and there is a rudimentary *corpus callosum*. In points of their structure they seem to be intermediate between the primitive mammals and the perfect mammals, yet authorities do *not* hold that the *existing* marsupials are in the direct line of the evolution of perfect mammals.

Living marsupials are regarded as a side line.

But so numerous were their ancestors that the present families, at any rate, help us to see the gradual stages by which perfect mammals may have arisen, for they appear to have come through a marsupial group.

We can form a fairly clear idea from the duck-mole and the kangaroo how the whole class of mammals have arisen from reptiles, but when we turn to geology we find the case greatly strengthened. In the Triassic strata of rocks we first meet with the remains of undoubted mammals. They first appeared on the earth in a "tentative and hesitating way; they shrank from observation and destruction by their small size." Then the world abounded in carnivorous reptiles. The early mammals lingered to quite a recent period (the Eocene).

Some of these early forms had many points of resemblance to the classes represented by the duck-mole and the kangaroo, but now it is generally held that they form an earlier order which may possibly have embraced the ancestors of both duck-mole and kangaroo. This early order has been

called Other-mammals (Allotheria). "These first mammals were marsupials" (*Geike*, p. 1083), and they remained the highest types that were reached before the beginning of the Tertiary period.

In the next bed of rocks above—*i.e.*, the Jurassic—three groups of small animals have been found. One of these groups contains *the Primitive Insect-feeding animals*. One of these animals (amphi-

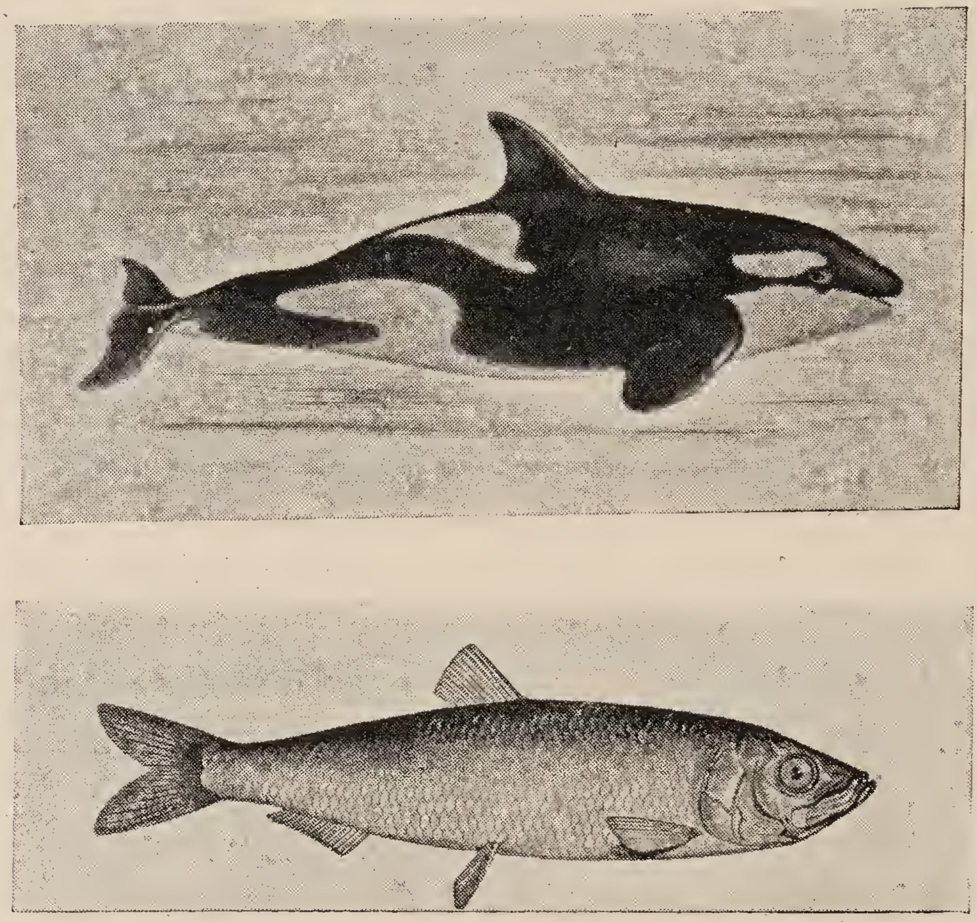

FIG. 136.—A Whale and a Herring.

therium prevostii—found in Stonesfield slate, near Oxford) was a creature about the size of a rat.

Our present insect-feeding animals, together with our carnivors and *ungulates*, or hoofed animals, can be traced back to the Eocene period, to a group of flesh-toothed (creodonta) reptiles, and to *ungulates* represented by the phenacodus.

The early *perfect-mammal* stock consisted of small

animals, with small heads and slender long tails. The limbs had five toes, teeth were forty-four in number, and they had a small brain. To these animals we shall return.

But before we deal with our ancestors it would be well to dispose of two remarkable groups of mammals.

In Fig. 136 the two animals look very much alike, but one is a fish and the other a mammal. The top one is a whale, called the Killer; the bottom one is a herring.

Now, it is sometimes news to people when they learn that the whale is a mammal; but such is the undoubted fact. The teats of the mother are towards the tail-end of the body, and she holds her young up by a sort of flipper, while she squeezes the milk down its throat.

There are many families in the class of whales. Perhaps the best known is the rorqual.

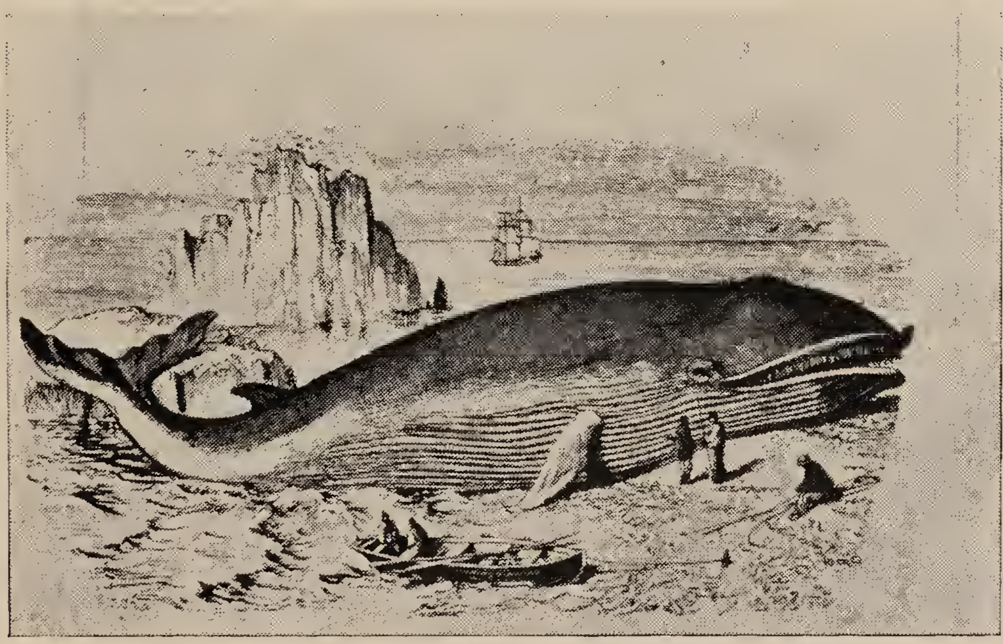

FIG. 137.—The Rorqual or Whale-bone Whale.

You can see what a gigantic beast this is. It has been known to measure eighty-five feet in length, and to weigh several tons. Most people

are familiar with whale-bone, which is not bone at all. The so-called whale-bone is a horny product of the lining of the mouth, where it is found in huge transverse ridges. In 1897 this stuff was worth £2,000 a ton ; and, as a single whale would yield several tons of it, we can easily understand why people took up the dangerous pursuit of whaling.

Fig. 138.—A Flying Mammal—the Bat.

The larger kinds of whales are so heavy that they cannot live on land, as their own weight prevents them from breathing.

The position in which whales ought to be placed in any system of classification of mammals is very hard to determine, and is not yet settled. They appear to be almost isolated, like the sirens and the sloths and armadillos. Time will doubtless show us some connections.

Above (Fig. 138) the bat hangs curled up, while below we see him with his leathery wings extended. There are many families, and they are found all over the world; and there are more than 190 species of one family (the Vespertilionidæ). This large order of mammals was once placed in the same

FIG. 139.—A group of Insect Eaters.

order as man; but time and toil have shown that it is a distinct order, and probably a side line, as no fossil forms yet found bridge over the gap between bats and the highest mammals.

Leaving these side lines, we turn to our main line, along which most mammals travelled. This

main line is called Insectivors, because they live on insects.

Fig. 139 shows three common but most interesting insectivors. The small animal at the top is the shrew *(sorex)*. They are often called shrew-mice, but they are not mice. They are a very old family, and very widely spread. One of them, the *sorex minutus*, is the smallest British mammal.

FIG. 140.—Water-Shrews.

The larger animal, in the middle, is the common mole *(Talpa Europæa)*. It is found only in the Old World. There are mole-like creatures in America.

The bottom animal is the hedgehog *(Erinaceus)*. It not only eats insects and slugs, but also chickens, young game birds, and vipers.

The three animals in Fig. 139 should be care-

fully studied in some good book on zoology, and also as living objects if possible. They are among the most interesting of English animals, because of their enormous antiquity, and because they throw much light on the kind of small mammals from which the larger mammals have sprung, and in this way are of great service in helping us to understand a little of the remote ancestors of man.

Fig. 140 shows water shrews, which are larger than the common English shrew. They are not

FIG. 141.—The Weasel-Ape (Galeopithecus).

"true shrews," but are classified under the family of the moles. They have a great interest, because in several ways they connect moles and shrews.

The striking animal shown in Fig. 141 has sometimes been referred to the class of lemurs, sometimes to the class of bats, or has been made the type of a special order of mammals. Dr. Beddard says: "It is better to regard it as an aberrant insectivor—so different, indeed, from other forms

that it requires a special sub-order for its reception."

It is a larger animal than any other insectivor, and is about the size of a cat. It inhabits the Oriental region. It has remarkable folds of skin (the patagium) between the neck and fore-limb, between the fore-limb and the hind-limb, between the hind-limb and the tail, by means of which it is able to fly. The patagium of this creature is mid-way between that of the flying-squirrel and the bat.

In this and other ways it is a real connecting link, and the utmost interest attaches to the fact that it is distinctly connected with Lemurs.

Shipley and Macbride, in their excellent book on zoology, say: "The most interesting circumstance about the insectivors is the fact that when, by means of fossils, we trace back the higher groups of mammals, they *all* seem to merge imperceptibly into insectivors—*i.e.*, the *primitive* insect-eaters.

"There is really good ground for supposing that the living insectivors, though modified in special details, nevertheless represent, so far as their general organisation is concerned, the earliest type of (Eutheria) perfect mammals which appeared on the globe. From these original insectivors advance seems to have taken place along five lines:—

"I. Some insectivors took to attacking larger prey, including their own less fortunate relations, and gradually developed into the Carnivora, or flesh-eating mammals. These are tigers, cats, dogs, wolves, etc.

"II. Some became vegetable feeders, and gave rise to the great group of hoofed animals, relying either on their swiftness, or size, or strength, for defence. These are horses, cows, elephants, etc.

"III. Some took to burrowing, and developed into gnawers or rodents, relying chiefly on their holes for safety. These are rabbits, rats, mice, squirrels, etc.

"IV. Some took to the air, the fore limb becoming changed into a wing. These are the bats.

"V. The remainder took to escaping into trees when hard pressed, and eventually gave rise to the great group of the Primates, which includes monkeys and man."

Leaving the first four groups as side lines of

FIG. 142.—The Ring-tailed Lemur, known among sailors as the Madagascar Cat.

evolution, we will devote our attention to the Order Primates. This name means the first or highest order. All zoologists now agree that lemurs, monkeys, and man must be classed in one and the same order. This fact is in itself a remarkable testimony to the truth of the doctrine of evolution.

This highest order, the Primates, has been divided into two sub-orders :—

The first Sub-order is the Lemuroidea—*i.e.*, the lemur-like animals.

The second Sub-order is the Anthropoidea—*i.e.*, the man-like animals.

Now, instead of giving you a dry catalogue of the various points of resemblance or difference, I am going to show several of these animals, that you may see, in a measure, how it is possible for apes to have developed from insectivors.

There are three families and four sub-families of lemurs. Lemur means a ghost. In Latin, lemurs

FIG. 143.—The Black Lemur.

meant the spirits of the dead. Many of these animals come out only in the night; they are silent and mysterious, ghost-like; so Linnæus named them lemurs.

One family, the Idris, found only in Madagascar, has much larger hind limbs than fore limbs; the ears are short, the tail varies in length, the thumb is but slightly opposable, and the toes are webbed. When these lemurs progress on the ground they

do so by means of their hind limbs, holding their arms above their heads.

In Fig. 142 observe this animal has flat nails on all its fingers except the forefinger.

Fig. 143 is a mother with her young one, if you can see it lying across her belly. The young lemur is often carried in this way by the mother; its tail

FIG. 144.—Three Lemurs.

passes round her back, and then round its own neck. It has been suggested that the mother may have got this instinct from her pouched ancestors, which used to carry their young in a pouch, as you have seen the kangaroo still does, in Fig. 135.

In Fig. 144 the topmost one is the ruffed lemur, and is of the same sub-family as those shown in the two former figures.

The middle one is the dwarf lemur, and the bottom one is the mouse lemur. These two belong to the same sub-family (Galagininæ) as the squirrel lemur.

There are five species of this mouse lemur. They are found in Madagascar, and all the lemurs of Madagascar differ from the African lemurs in the structure of the ear.

You will observe that the last three specimens,

FIG. 145.—Another Mouse Lemur, with its very long tail.

though they have nails on all their fingers, have a claw on the second toe.

The loris belongs to quite a different sub-family of lemurs. This sub-family has a wide distribution, and, excepting one other (Tarsius), it contains the only Asiatic members of the group. They are small animals with a very short tail, and in some of the group there is no tail. The index finger is small, and never provided with a nail. Notice the

thumb, which diverges widely from the other fingers; and the great toe diverges so much as to be directed backwards. (Fig. 146.)

The upper form in Fig. 147 is the loris awake, and the bottom one is the creature asleep. This species is confined to India and Ceylon. Judging from this picture, sleeping in trees is not the highest form of luxury.

The aye-aye, again, is from Madagascar. It is a most remarkable animal, and you should study it well (Fig. 148). As you look at it you are reminded

FIG. 146.—The Slow Loris.

of a squirrel. You note its long, bushy tail, and the great length of its hind limbs; there is one pair of abdominal teats in the female; the third finger is singular, being much longer than the others and very thin; the thumb and the big toe have flat nails; all the other digits have claws.

This animal is one of those which are the despair of the people who wish to make a cut-and-dried arrangement of all the world, for it offers links to so many different animals.

Its teeth are unlike lemurs; they are more like those of rodents: there are no canines.

It is a mysterious animal, and there are many superstitions about it among the natives. At one time it was feared it might die out; but the natives so reverence it that they are afraid to catch it, and consequently it is now increasing in numbers.

From these numerous examples of this important group you are able to see the great varieties of structure the lemurs offer. It is almost as if Nature

Fig. 147.—The Slender Loris.

were trying experiments with infinite variety of detail. You must be convinced how very near this Lemur group is to the group called Insect-feeders. But we have dealt only with living lemurs. What is the message from the rocks about extinct lemurs? I quote you some remarkable words from A. S. Woodward's standard work on palæontology.

He says the small insect-feeding mammals "are probably the little altered survivors of some of the

most primitive *placentals*"—*i.e.*, animals whose young are developed in a membrane called "the after-birth."

When he comes to the Order Primates he says: "Several of the extinct insectivores and lemurs apparently constitute a distinct link between this group and the insectivores." Of the lemuroids he says: "The lemurs are clearly of a lower grade than apes (or Anthropoidea), and some of the extinct genera, commonly referred to lemurs, are doubtless to be regarded as the direct ancestors of the higher group.......In the *Eocene* period these animals lived not only in Europe, but also in North America; while at the present day they are

FIG. 148.—The Aye-Aye.

exclusively confined to Madagascar, parts of Africa, and the Southern Asiatic region. They seem to have become extinct both in Europe and North America at the dawn of the Miocene period, when apes began to appear, at least in the Old World."

Having clearly shown that the lemurs are closely related to those little early mammals, the *primitive insectivores*, we have now to inquire how the lemurs are related to the class next *above* them. This second great division, called the Sub-Order

Anthropoidea, means the man-like animals. It includes all the monkeys, apes, and man.

There are 212 species of monkeys and apes, and they are all divided into two groups—called the Platyrrhines and the Catarrhines. We must be clear about the meaning of these two words.

Platyrrhine means flat-nosed.

Catarrhine means down-nosed, or narrow-nosed.

In Fig. 149 the top one on the left and the bottom

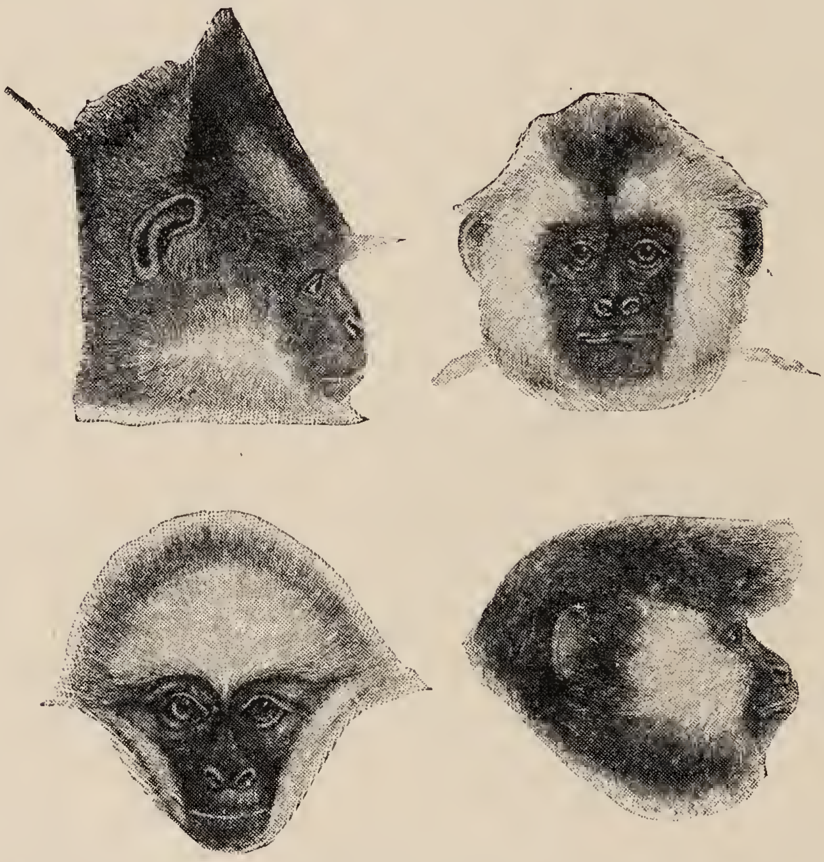

FIG. 149.—Representatives of both families of the Man-like Monkeys.

one on the right are catarrhines. You observe that in the top one, on the right, and the bottom one, on the left, the nostrils are not only flat, but turned slightly outwards; these two are platyrrhines.

This group also shows the odd arrangement and development of the hair on the head.

Some very wonderful facts are offered for reflection in these two divisions.

It is wonderful that all the monkeys and apes in the world can be divided by their noses.

It is also remarkable that all the flat-nosed are found in America, and nowhere else ; while all the down-nosed are found in the Old World—Europe, Asia, and Africa—and nowhere else.

This is one of the clearest, sharpest divisions in nature, and there is, perhaps, no single exception.

What is equally wonderful is the fact that these

FIG. 150.—Marmosets.

two groups have been absolutely distinct for vast ages, as no fossil remains of intermediate forms between them have yet been discovered. Grasp, if you can, this amazing fact, that in a far-distant past these two groups of animals arose, and each developed on its own line, never to meet the other again. Whether they arose from the same group or from two different groups, their present position is equally marvellous.

We will consider, very briefly, the flat-nosed American monkeys first, for they seem to stand at the base of the whole series, and show the connection between lemurs and the monkey family. This is another example of the existence of very ancient creatures in South America. But remember the flat-nosed monkeys are not in the direct line of man's ancestors. They are a side line.

Though we must remember that the flat-nosed

FIG. 151.—Marmosets (silky).

monkeys are a *side line*, as far as man is concerned, yet they are interesting as showing some of the common features of the common ancestors of both.

The marmoset belongs to the lowest family of all the monkeys (Figs. 150, 151); the fingers and toes are, for the most part, *clawed*, only the great toe bears a flat nail; the tail is ringed, as is often found in the lower groups of mammals, but not in the higher

apes. There are two genera, and about twenty-one species of marmosets.

All the American monkeys come under the name of "Cebidæ," from the Greek word *Cebus*—a long-tailed monkey.

In Fig. 152 the one at the top is the spider-monkey, clinging on to a branch with his tail.

The one at the bottom, on the left, is the red-faced

FIG. 152.—Group of Cebidæ.

Ouakari. He has quite a sad, poetic expression of countenance.

The other, on the right, is the white-nosed saki. There are five species of sakis ; and, though their tails are long and bushy, yet they are not prehensile —*i.e.*, they cannot grasp objects by them. They are bearded, and they have a thumb. One species is very interesting, because it uses its hand to drink, instead of putting its mouth to the water, as the other species do.

The squirrel monkeys are small creatures, with long heads and short thumbs.

FIG. 153.—The Squirrel Monkey (Chrysothrix), known as the Golden-haired Monkey.

In this family it is very remarkable that the size of their heads, in proportion to their faces, is greater not only than in other monkeys, but than in man

FIG. 154.—Head of short-tailed Squirrel Monkey.

himself (Fig. 154). Humboldt asserted of one of them that, when vexed, its eyes filled with tears. How human !

Fig. 160 shows six objects; the top row, beginning from the left, shows the human skull; in the middle the skeleton of the woolly monkey (Lagothrix); and on the right the skull of the woolly monkey. This is, perhaps, the most human-looking skull ever found outside the human family.

The bottom line reads from the left:—

The skull of the macaque, one of the largest of the Asiatic monkeys; the middle one is the gorilla; and the one on the right is the baboon.

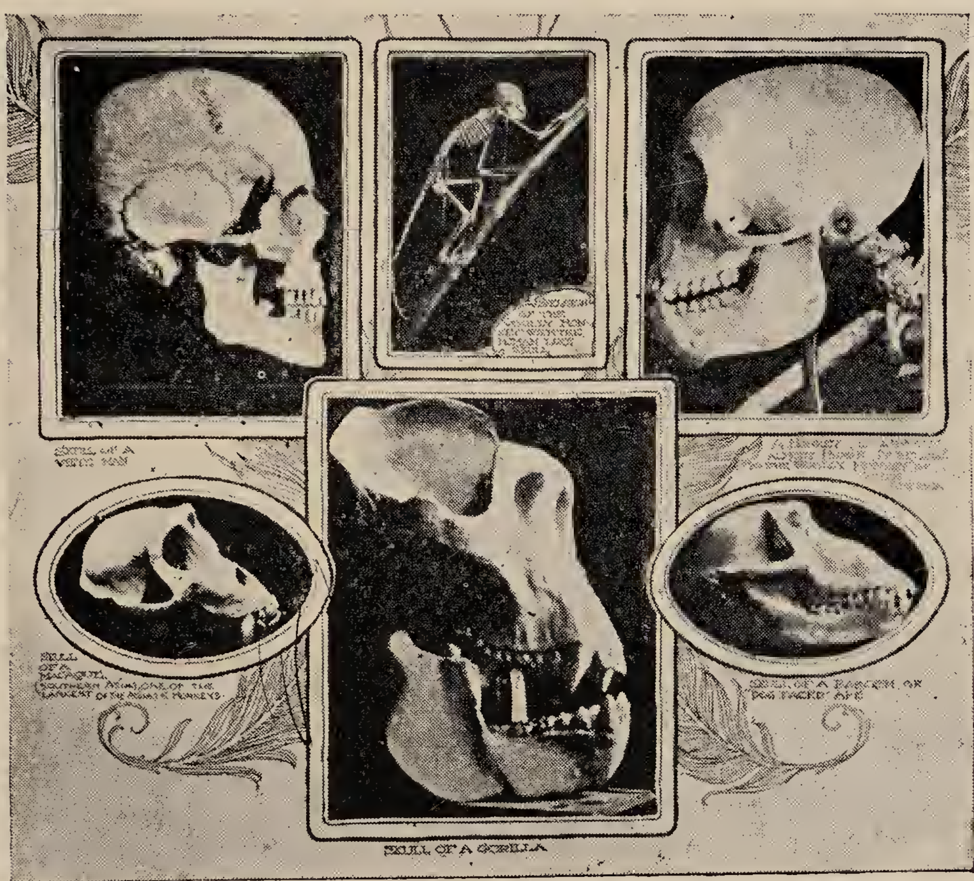

Fig. 155.—The Woolly Monkey and others.

All in the bottom row are, more or less, dog-like. This is caused by the projecting of the jaws so far forward as the animals grow old.

Of course, none in the bottom line are American monkeys, or belong to the flat-nosed group.

We turn from this flat-nosed group, which is a *side line*, to a far more interesting inquiry—viz., the Catarrhines, the down-nosed apes. These are

of remarkable interest to us, for there appears to be no doubt that they are *near blood relatives* of ours.

The *down-nosed apes* are divided into three families :—

(1) The tailed apes.

(2) The Anthropoid or man-like apes (Simiidæ).

(3) Man.

(1) Under the lowest family, the tailed apes (Cercopithecidæ), we will notice three kinds.

FIG. 156.—The Woolly Monkey.

In Fig. 157 the Tcheli monkey, on the top, is striking in many points—its dog-like body, its short tail, its baby-like hands, and its John-Bull expression of face. This monkey is found in North China. It is interesting to note that, like the tiger of the same region, it has put on an extra coating of fur to enable it to bear the bitter winters there.

On the left is the Diana monkey of the genus

limited to Africa. There is quite a respectable, professional air about this species, with its fine white beard and aquiline nose.

On the right is the Entellus, one of the sacred apes of India.

(2) Passing to the next family (the Simiidæ), we come to the man-like apes. They differ from the former in but slender points, yet they move in the direction of the human form.

"In this family the tail is completely absent, the arms are longer than the legs, and the gait might

Fig. 157.—Group of Monkeys.

be described as that of a baby learning to walk. They never go completely on all-fours, but usually shuffle along unsteadily on their two feet, which, like those of a baby, show a tendency to turn inwards under them; they usually steady themselves either by means of a stick or by bending forward so that their knuckles touch the ground" (Shipley and MacBride).

Mr. Beddard indicates some of the points in which this family of man-like apes differs from the family below them and approaches nearer to man, thus :—

Though they live in trees for the most part, yet when on the ground they progress in a semi-erect fashion. When they put their hands on the ground to aid them in walking they do not rest, as do the lower apes, on the flat of the hand, but upon the back of the fingers. The hand, in fact, is growing less like a foot in its use.

None of this family have a tail or cheek pouches. The hair is rather more scanty than in the former family. The placenta, or after-birth, differs in

FIG. 158.—The Hoolock, one of the Gibbons.

detail from that of the lower apes, and is exactly like that of man.

Their arms have a greater length as compared with their legs than the family below them.

This family is divided into four groups :—

The gibbons.
The gorillas.
The chimpanzees.
The orangs.

The Gibbons (Fig. 158) are the smallest, standing

quite at the base of existing Anthropoid apes; and they are the most truly tree-frequenting of all this family. They have very long arms. They range through South-Eastern Asia. These animals can walk erect; and when they do so the big toe is separated, as in man when the toes are not cramped together by wearing boots.

Beddard describes the gorilla (Fig. 159) thus:—

"The face is naked and black; the skin generally

FIG. 159.—The Gorilla, an African animal.

is deep black, even at birth. The ear is small; it is more human in form than that of the chimpanzee. The nose has a median ridge; the nostrils are very wide. The hands and feet are short, thick, and broad; and the heel is more apparent than in the other higher apes. This is associated with his mode of walking on a flat foot. It is interesting to find that the muscles of the little toe are diminishing in the gorilla as in man; this is evidently due to

leaving trees and walking on the ground, and not to tight boots. In fact, owing to his more erect gait—for he can readily assume the upright posture —many of his muscles are more like those of man."

The gorilla is found only in the forest tract of the Gaboon, Equatorial Africa. It goes about in families, with but *one* adult male, who later has to dispute his position as leader of the band with another male, whom he kills or drives away, or by

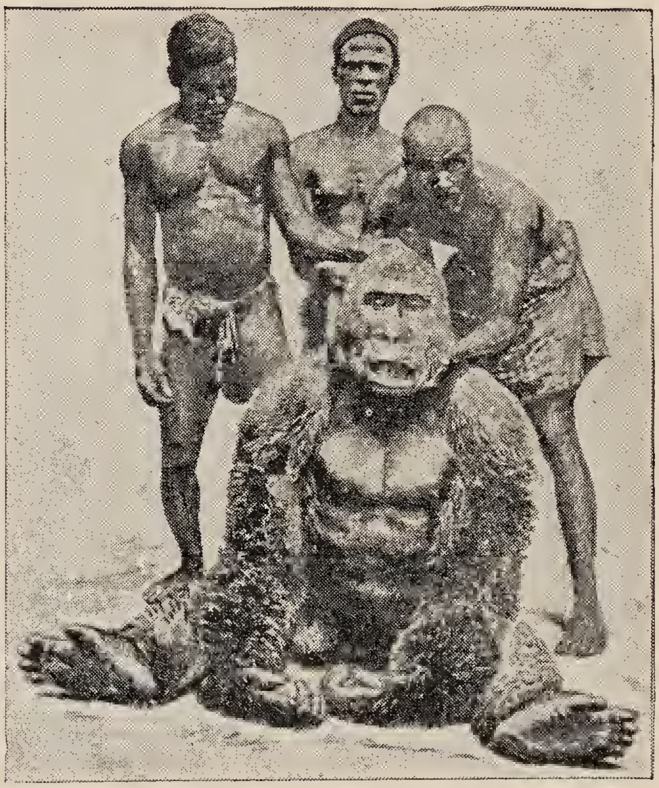

FIG. 160.—Giant-gorilla held by three negroes.

whom he is killed or driven away. The gentleman is a polygamist. He is the largest of all the apes, reaching a height of five and a half feet.

It may be of interest to note that the fierce gorilla is a vegetarian, while the chimpanzee is a flesh eater.

But the recently found giant gorilla (Fig. 160) greatly exceeds the others in stature. This giant gorilla was killed in the interior of the Cameroons, at Yaunde, by H. Paschen, and is now in the

Rothschild Museum at Tring. The total length of its body, from the top of its head to its middle toe, is six feet nine inches.

FIG. 161.—A group of Gorillas at play.

Fig. 161 should teach us how little we know of these animals from merely looking at one solitary caged-up specimen. There are many school-boy touches in this group, and a great deal of human expression.

We must pass to the chimpanzee, also an African animal. In many points it resembles the gorilla—"there is scarcely a feature in any muscle or bone found in one animal which is not found in the other."

Sally (Fig. 162) is taking her porridge in a very human fashion.

In mental characteristics there is the widest difference between the gorilla and the chimpanzee.

The latter is lively, teachable, and tameable; but the gorilla is gloomy and ferocious, and quite untameable.

"The general conclusion concerning the relative

FIG. 162.—The well-known Chimpanzee, "Sally," late of the Zoological Gardens, London.

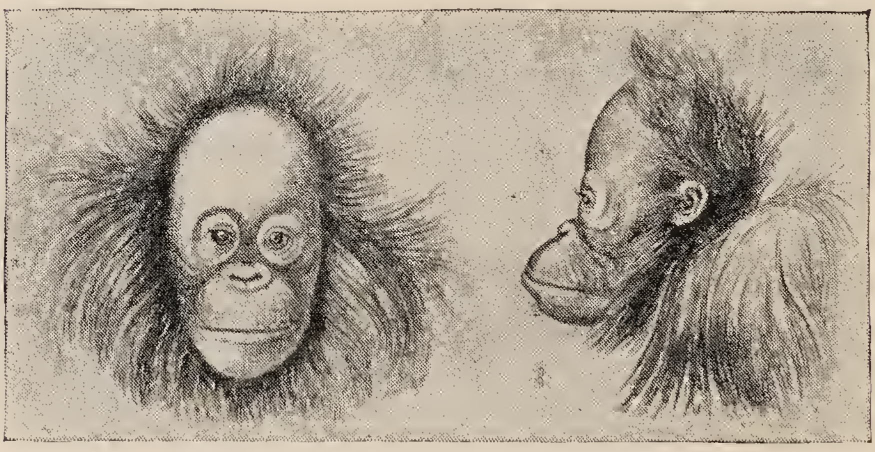

FIG. 163.—A young Orang.

position of these two African anthropoids seems to be that the *gorilla* is the more primitive; and, as thus it must approach more nearly to the original

parent than does the chimpanzee, it may be said that it also comes rather nearer to man, since the chimpanzee has travelled away from the common stock on another line."

Our last division of these interesting cousins is the orang-utan.

Observe the amount of upper lip which has been lavished on all this group (Fig. 163). Otherwise the boy hath an open countenance! Orangs are found in Borneo and Sumatra.

FIG. 164.—Orang sitting in its nest.

It is important to note the young head because, in the adult skull, this human look has sometimes nearly passed away, owing to the great increase of the size of the jaw and to the fact that it is pushed very far forward. You see the adult goes back to the older and fixed features of the race, and you can often notice this fact, in other features, in human beings as they become very old.

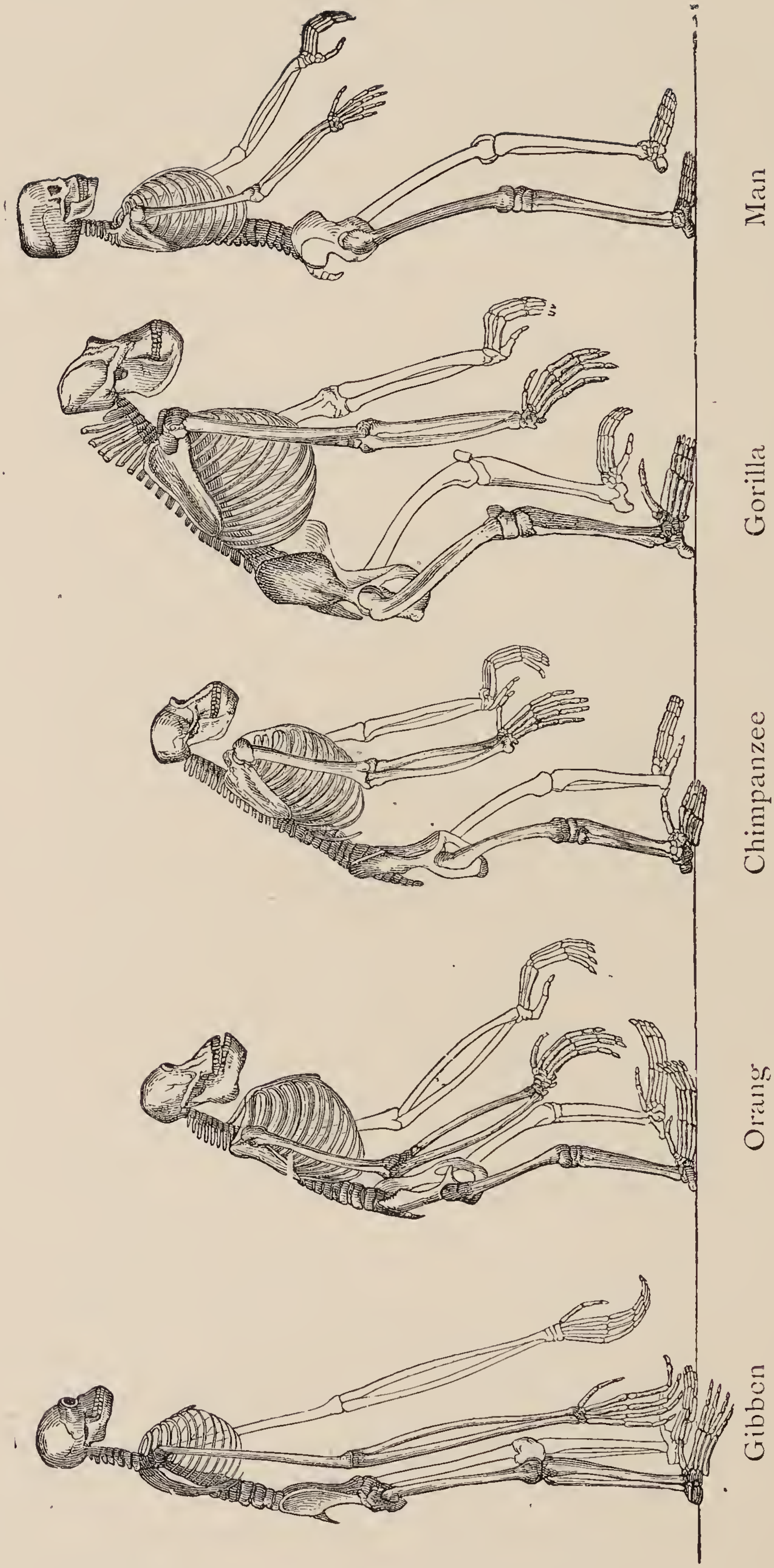

FIG. 165.—The Skeletons of Gibbon, Orang, Chimpanzee, and Gorilla, with Man in front.

This ape inhabits flat and forest-clad ground, and lives mainly in the trees. The male leads a solitary life, except at the pairing season; but the female goes about with her family. Every night, or every second night, the animal constructs a new nest for himself, abandoning the old one (Fig. 164).

The orang is a large and heavy ape, particularly pot-bellied, and with a melancholy expression. The ears are very small and graceful in appearance, pressed closely to the sides of the head. The arms

FIG. 166.—The long-nosed Ape.

are so long that, when the animal is standing, they reach as far as the ankle. The big toe is very short, and usually without a nail.

Upon carefully studying these skeletons, few people would doubt that they are all rightly placed in one order, unless you told them first that one of the skeletons was man (Fig. 165).

Our experience of apes and the low races of man is so small that our notions of both are very incorrect. Few people are familiar with the acts of

extraordinary intelligence performed by monkeys and apes. One variety has been trained to climb the cocoa-nut palms, and to carefully select and throw down only the ripe fruit.

On the other hand, the lowest races, in their dull, brutal, unreasoning lives, are things inconceivable to some of us.

In Fig. 167 we have the long-nosed ape and Miss Julia Pastrana.

If any gallant champion comes forward to maintain that the lady is the more beautiful, I should shrink from contesting the point with him. Julia Pastrana used to appear in the music-halls of Paris.

FIG. 167.—The long-nosed Ape and Miss Julia Pastrana.

Reading from the left, in Fig. 168, the top two are the chimpanzee and the gorilla ; the bottom two are the orang on the left, and the negro on the right.

Consul performed in London till his death in 1904. The fact of his being clothed takes off a good deal of the striking difference between ape and man.

Reading again from the left (Fig. 169). In the top line we see him out for a walk with his valet ; next, off to Brighton with his portmanteau ; below he is riding a bicycle, and finally, rather wearied, he sits in an arm-chair. He was insured for

£20,000. One can hardly resist a parody, and say it is a pity that apes are so dear and men so cheap.

For many centuries we have so despised the lower animals that we have comparatively few records of their reasoning powers and their civilised habits. So long as it was held that man differed *absolutely* from every other animal, so long it was impossible to understand the other animal, or man.

FIG. 168.—A group of Apes with a Negro.

The cases which I have shown you are not the extraordinary exceptions which they may seem to be.

Bishop Taylor-Smith, the Chaplain-General of our forces (March 30th, 1904), has a clever little monkey, which sits down to dine with him, can feed himself with either hand, and behave like a little gentleman.

Another ape, Consul II., rivals the departed

Consul I. He is a chimpanzee of Borneo. At the age of one year he had been taught to sit up at table, to use a knife and fork—having first carefully tucked his napkin under his chin—to drink from a cup, to remember his table manners, and keep his feet under the table instead of on it. He likes an after-dinner pipe. Dinner over, he gravely wipes his mouth on his napkin, climbs down from his high chair, settles himself comfortably on a stool,

FIG. 169.—Consul: A Chimpanzee.

picks up his filled pipe, takes a light and lights it, and enjoys his smoke. He can polish shoes carefully, and expects his penny when he has done. He washes himself with soap and water, and can get into his trousers and coat without help.

The mere fact of dress alone has prevented us from seeing many points of likeness between our more hairy relatives and ourselves.

Let us look at a few of the human race who are not burdened with fine fashions in dress.

FIG. 170.—A Galla boy nine years of age. (From Africa.)

Observe how the head slopes backward and the lower jaw and the mouth project, reminding us very much of the apes.

FIG. 171.—A Hottentot chief and his wife.

Here you observe very much the same features in her. The mouth projects, the head goes back.

FIG. 172.—The chief of an African tribe, the Lomani.

This chief has decorated the upper lip; but observe the length of his jaw from the ear to the chin.

FIG. 173.—An African Negress who wears a lip-plug.

The lip-plug is a piece of adornment, which may not become common in this country; but, at any

FIG. 174.—An Australian lady from New South Wales.

FIG. 175.—A native of New Guinea.

rate, it is more humane than plucking feathers from *live* birds, with which to adorn hats.

Observe the long upper lip in Fig. 174, which has been so marked in most of these low races, and which was very marked in the orangs. Don't quarrel with your wife if she has a lip like that!

Fig. 175 shows a peculiar animal-like mouth, and a flat nose. The mouth is a tell-tale feature, and it would be worth much to some people if they could

FIG. 176.—Some natives from Queensland, Australia.

conveniently hide their mouths. Again we are struck by the flat nose and the brutal mouth.

Before we are horrified at, or ashamed of, our ancestry, we ought to study hundreds of the lower races of men, and we should find that the separation between the higher animals and the lower men is by no means as great as the ignorant suppose.

Chapter VI.

AN OUTLINE OF THE LAWS OF EVOLUTION

So far as little as possible has been said about the laws of evolution. In astronomy we saw that worlds had evolved, and are yet evolving, by the condensing of the lightest known gaseous substance. We know how suns and moons are produced.

Coming nearer home, and giving attention to our own small world, we saw that the upper crust of the earth has been slowly formed, layer upon layer, *after* it had cooled sufficiently to have a solid envelope or coating all round it. In these layers of rocks we read the tale of life. Beginning at the lowest depths of stratified rocks, we found the remains of animals, but not the same kind as the animals we see around us. The fossils of that early period tell the story of races that have disappeared. As we come nearer the present surface of the earth, and therefore nearer to modern times, by the aid of the fossils found, we see the change which millions of years have produced. Just as the lowest rocks show us remains of animals *unlike* any we now see, so the rocks nearer the surface show us animals more like those of our own time; till, in the topmost rocks, we find in several cases that the animals of a few thousand years ago so closely resembled the animals we now see, that they can be arranged in the same groups.

Now, this of itself is not a sufficient proof of evolution, perhaps. But, at any rate, it shows us

that changes from the earliest animals to those of our own time are gradual changes, and that they are connected changes. It proves also beyond all doubt that the simple, small forms came first in the world's history; and that, just as the bicycle has gone on improving, so the low forms of animals died out and gave place to better forms which had sprung from them by slow changes in advantageous directions. The dying out or extinction of so many animal groups is perhaps one of the most astounding lessons which the rocks teach us.

Further, we have seen in looking at living animals that, if we begin with small creatures which are merely *one* cell of jelly-like matter, we can trace them up to man, not by a single step, but by many steps. We have seen that there is no hard-and-fast line betwixt all the groups, but animals occur which are partly like a group below them and partly like a group above them.

Now, we saw that a piano and a rifle both evolved from the bow and arrow. Some of the principles upon which a piano and a rifle are constructed occur in the bow and arrow; but they are somewhat mixed and undeveloped. The bow and arrow in this sense are "generalised"; but after many years of improvements and inventions, on two quite distinct lines—one for music, the other for killing—we see two instruments so unlike that a century ago probably no one suspected that they had come from the same thing. Now, if this has happened in the few years known to history, what may not have taken place in the evolution of *living* things in the millions of years?

In trying to grasp the great principles of evolution we may take two opposite points of view. We can look at small, low animals, and see what is the

nearest group above them, noting their points in common, and also any new points in the higher group. Thus we form a ladder, and mount step by step to civilised man.

On the other hand, we may take the best developed man we know, and look at all the fixed parts of his body and trace them back to their origin. For instance, the backbone is common to the human race; but we know there was a time when no animal had a backbone. Therefore, wherever we find this backbone we find a common structure of a very large family, and we know that it is most likely that all these backboned animals came from the same group of ancestors.

Or, again, take the five fingers, the four limbs, the brain, and many other structures. We know that animals lived, and still live, having none of these structures; and, as we learn how they were acquired, so we discover the low ancestors of the higher animals.

Of the numerous variations which occur in young animals, some perish with the young themselves; but other variations, proving helpful in the struggle for life, not only are a benefit to the young, but are handed down to their offspring; and in time they become greatly developed and fixed, till, in the course of ages, two sets of animals which came first from the same group, by developing on two different lines, become as distinct from each other as pianos from rifles.

All who wish to understand evolution must begin to look for themselves at the common points which bind together the most unlike animals, until the mind is trained to grasp the relationships of the whole animal family. A good way of beginning this is to study your own family and relatives.

Note how a child may have one striking feature of its father, another of its mother, or blend both so that, instead of being strikingly like either parent, it shows but little resemblance to them—presents a new variation ; or there may be some oddity of appearance or manner, strikingly like the child's grandparent, or even the grandparent's grandfather. Such striking features will often run through many generations.

Another good way is to attempt to find a group of animals which is totally unlike any other group ; for in this way we soon learn that such a group can never be found.

One species shades almost imperceptibly into another species. One genus, separated by ten thousand years, is found to have come to life by thousands of changes—branches in the tree of life, we may call them. There is only one explanation yet known of this marvellous network of living and once-living things. The explanation is that they are all of one family, by descent, and that all the striking changes have come to pass through gradual modifications. This "descent by modification" is known as "evolution." Scarcely any intelligent, well-informed persons can be found now who do not admit the *fact* of evolution, whether they know how it arose or not.

The fact of evolution is explained chiefly by five great laws, not one of which any one can deny.

First Law, the law of heredity.—Like produces like. Sheep produce sheep ; cats produce cats ; the children of one family do not resemble the parents of another family—they resemble their own parents. This is the law of heredity: it has been known thousands of years ; and every sane man admits it and acts upon it.

Second Law, the law of variation.—The children of the same family are not all exactly alike, neither are they exactly like their parents.

This law seems to contradict the law of heredity, and it does to a small extent, because the outside forces, which we name environment, are never exactly the same in their action upon different individuals. The forces of environment are the chief factors to produce the variations which make evolution possible. If the offspring were always exactly like their parents, there could have been no improvement.

This law of variation has also been known thousands of years. No one doubts it. If any farmer were to kill all his stock which were not exactly like their parents, he would have no stock.

The causes of this variation are many, as we shall see later, and there may be causes *not yet known;* but the fact that offspring vary, little or much, is beyond doubt.

Nothing shows this more clearly than pigeons.

Now, it is agreed that all pigeons have been derived from the wild rock pigeon.

If we look at Fig. 177, in the centre, below the top line, you see two of these wild pigeons sitting on a rock, and you notice they are very unlike the others. For instance, look at the top line, where heads of the barb, the dragon, and the tumbler are. These heads are widely different from that of the rock pigeon.

All the others of this group vary much, till you come to the last, in the bottom row, on the right, called the frizzled, because its feathers, instead of being smooth, are rough and turned up.

In Fig. 178 look at the pouter, who seems to be struggling to carry a football beneath his beak;

and mark the fantail, which seems to be trying to bury its head in a fire-screen behind it.

For the power of variation you need no further object-lesson than this. With such a proof of

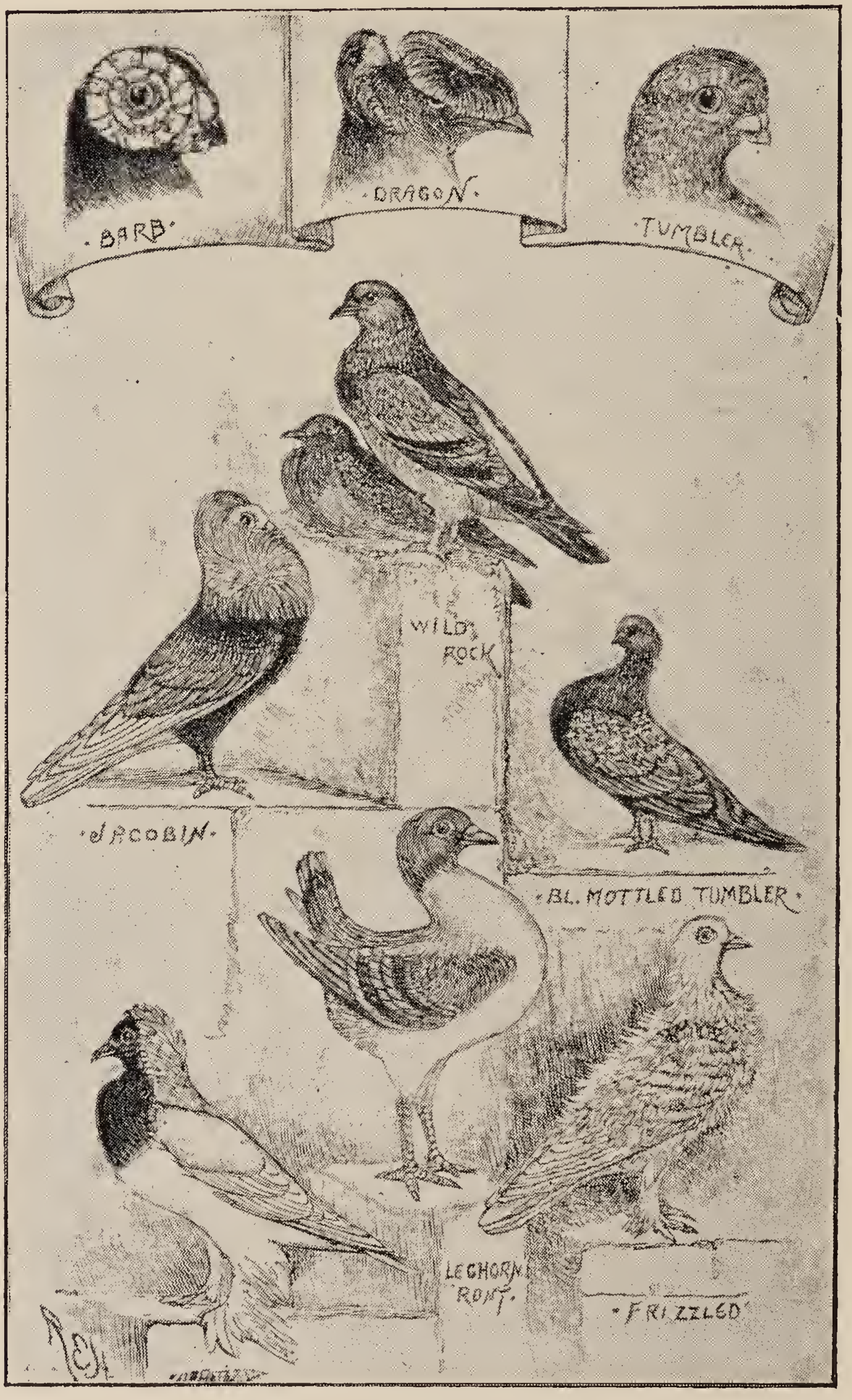

FIG. 177.—Pigeons. (After *Romanes.*)

variations from the same ancestors, we know that species change and that new species evolve. Of

FIG. 178.—Another group of Pigeons. (After *Romanes.*)

course, these changes in pigeons have been brought about chiefly by man's choice. It is called *conscious selection*, because man has selected the points or variations which he wished to develop.

When man selects, he chooses the points which are to his own advantage; when nature selects, she chooses the points which are to the advantage of the living creature itself.

The Third Law is, that more of all kinds of things come into being than can possibly live.

This law is so manifest that it needs little explanation. As Darwin says: "There is no exception to the rule that every organic being naturally increases at so high a rate that, if not destroyed, the earth would soon be covered by the progeny of a single pair."

Man has been known to double in twenty-five years, and, at this rate, in less than a thousand years there would literally not be standing room for his offspring.

What shall we say, then, of animals, whose increase nearly defies arithmetic? The cod-fish produces a million young each year; the oyster two millions; a tape-worm a thousand millions. Under no imaginable conditions could all these creatures live and go on reproducing, in a small world like ours.

The Fourth Law is that, in consequence of more beings coming into existence than can live, there is a struggle for existence.

As all the creatures cannot live, and as each desires to live, clearly they will struggle with each other for the best places, and for food. And as most creatures live on other creatures, the destruction is inconceivable. Darwin took a piece of ground 3 ft. long and 2 ft. wide, cleared it, and

then marked all the weeds that came up. Out of 357, not less than 295 were destroyed, chiefly by slugs and insects. A similar struggle rages everywhere, as most civilised people experience in their own efforts to make a living. If you doubt this, try to place twelve boys out in trades or professions. Or advertise for a clerk; you will have a hundred applicants: one may succeed, and ninety-nine will go back to fast and maintain a respectable appearance. Few of us have enough imagination to be able to deny the struggle for existence.

The Fifth Law is that in the struggle for existence the fittest survive. This Charles Darwin called "Natural Selection."

Note, when we say the fittest survive we do not mean the best according to any *ideal* standard. We mean those most suited to that particular occasion, or those most fitted to overcome the difficulties then present. If you have 1,000 people at a railway station, who have been to a football match, and the train that draws up can take only 600, clearly 400 will have to stay behind. Do you think the football team would be among the 400 left behind? And yet those footballers may not be the most philosophical, or poetic, or religious; but they have certain qualities which are of great service to people who wish to get into trains—so they are not left. This is the success of the fittest, or, as Herbert Spencer called it, the survival of the fittest.

Note again, by Natural Selection we do not mean conscious selection, or design, or conscious working for an end. Darwin's term, "Natural Selection," means that, in a world of struggling beings, natural forces will destroy some and leave others, so that the weak or ill-adapted are weeded

out. To give a homely example: if anyone were trying to rear chickens and ducks in a small yard, they might thrive in ordinary weather. But if a sudden deluge of rain came so fast that the water rose to the depth of two or three feet, the chickens would drown in their coops, but the ducks would swim about in great happiness. The ducks would be the fittest to survive a deluge of rain.

But, on the other hand, if chickens and ducks were being reared in a field with very little shelter, the chickens would take to roosting in the hedges or the trees, but the ducks could not. Now, suppose a hungry fox came that way some night, he would destroy the ducks; but he could not reach the chickens, and they would escape. Chickens are the fittest to survive in this case.

These illustrations are the more interesting because we know that chickens and ducks are *very nearly* related. They come from the same ancestors not very far back—an ancestor that was neither fowl nor duck, yet possessed some points of both.

Now, changes of circumstances such as I have here suggested are constantly taking place, and have been for millions of years. But it is quite clear that the creature entirely unfitted for the new circumstances perished. A very small thing might easily determine whether a race of savages or an individual poet should live or be destroyed.

Natural Selection is more powerful than our selection. It reaches far more widely. It is far more accurate. It is worked upon one single principle—viz., the advantage to the individual. There is no pity, no mercy, no dream of the good of the whole, in this process. It is deadly accurate, and cherishes the living because they possess the

requisite capacities to live. The favoured individuals, which have favourable variations, or which were in any way better adapted to their environment, would transmit these advantages to their offspring, according to the first law—the law of heredity. So each generation has a tendency to be better adapted to its surroundings.

When we consider that this process of killing many and preserving others has been at work for millions of years, we come to understand how the marvels of evolution are possible.

But perhaps there are still some who do not think that all living things are one family, and they ask, What evidence is there of this evolution?

We have seen, in the two previous chapters, that the animal world cannot be divided into small separate families or groups. Again and again we saw that one group shades away into another group, and in some cases a species of animal seemed to belong nearly equally well to two groups. This may cause despair to the man who wants to classify animals, but it is the surest kind of proof to the evolutionist that all these groups are only branches of the same family tree.

We have already seen what man has done by selection of various points in pigeons. By this means he has produced such varieties that, if they were wild birds, some of the varieties would be called species. The same lesson is taught us by all our domestic animals, by fruits, and by flowers. Queen Elizabeth lived not long ago; yet so great are the improvements made by selection and cultivation that we grow beautiful kinds of pears which she never saw; neither did she ever see a double chrysanthemum.

The animals in Fig. 179 belong to the same

group. Yet mark the enormous difference between the form of the wild animal and the white domesticated pig. This difference has been created by man in a comparatively few years.

This group of dogs (Fig. 180) teaches the same lesson.

No one supposes that each kind of dog was created at some particular period, separate from all

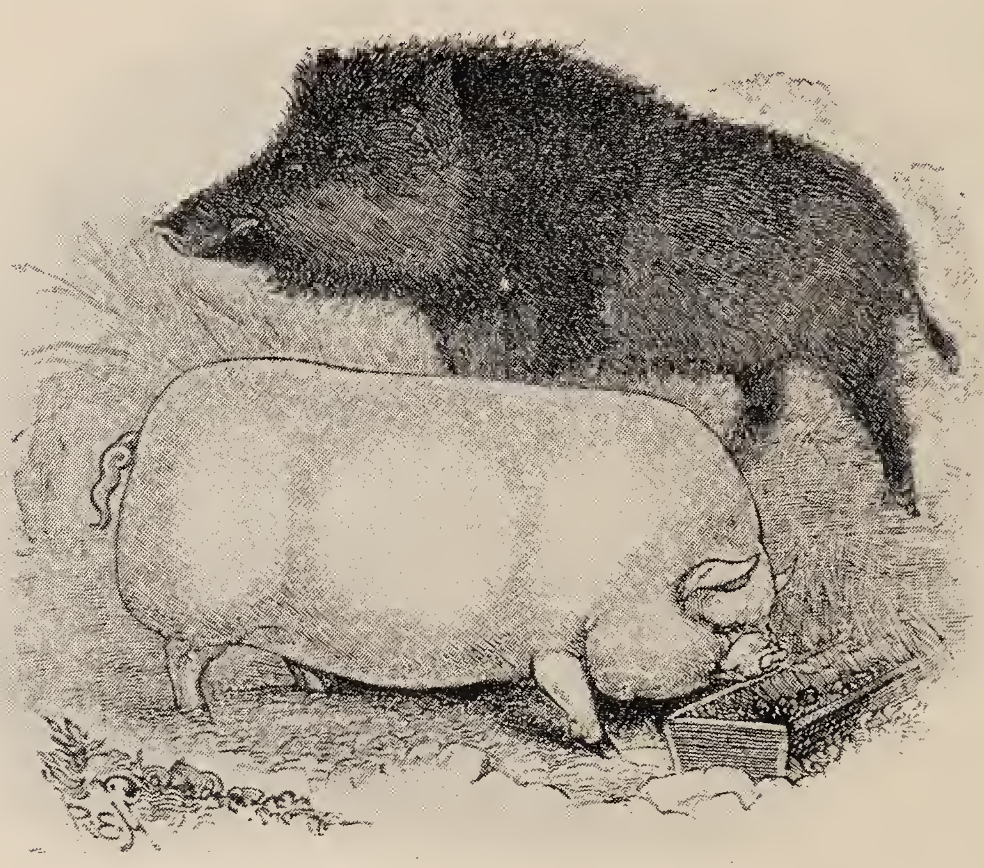

FIG. 179.—Two Pigs. (After *Romanes.*)

other kinds of dogs. All these animals are one family group, yet they are wonderfully unlike. Look at the greyhound and the pug, or at the bloodhound and the sky terrier; in so many points are they unlike that one might think they did not belong to the same genus.

In the case of domestic fowls the point is still more clearly seen. New and distinct varieties are

often formed by fanciers selecting the variations they desire.

Clearly, the old notion that species are fixed is not true. They can be modified in many ways.

FIG. 180.—Dogs. (After *Romanes.*)

We saw in the last two chapters how closely the various kinds of animals are connected, and by what small steps they are separated from each other. All this goes to prove that the various kinds of animals have arisen by small changes such as the theory of evolution would lead us to expect.

But perhaps the most satisfactory way of furnishing proof of the evolution of various animals from a common stock is to make comparisons with man. We find a remarkably close relationship.

Many points of likeness between man and other animals are easily seen. He requires food ; he digests it ; he throws out the waste ; he dies if cut off from air ; he requires the rest and refreshment of sleep ; he grows from infancy to maturity ; he reproduces his kind ; he decays in old age, and finally dies. In all these and many other points man is an animal, like the rest of animals.

Man and the other mammals are so alike that they are subject to the same diseases, such as lung fever, and they may be treated with the same medicines. They take each other's contagious diseases, such as hydrophobia, glanders, cholera, ringworm, and many others.

The higher we go in the order of animals, the more strikingly do they resemble man in the smallest details.

The skeletons in Fig. 181 are given to show the remarkable similarity in general plan. If you fix your attention on any one bone or arrangement in one skeleton, you will find a similar bone or arrangement in the same place in the other skeleton. So if you take the skeleton of a frog, or rabbit, or pig, the more you study them, the more remarkable will appear their resemblances.

FIG. 181.—Skeletons of Man and Gorilla. (After *Romanes.*)

Before we can consider the case for evolution to be established, we shall go into great detail on a few points. We must become familiar with the bones of animals, for they tell a remarkably clear story; we must inquire into the origin and growth of animals before birth; and we must take some of the most striking examples of peculiar organs which have been developed by special modes of life. All this, and much more, will form Part II. of our Picture-book on Evolution.

The group in Fig. 178 is a very brief pedigree of man. The full pedigree will appear in Part II.

1 is the mouse lemur, and represents fairly well the kind of little animal which an early ancestor of man must have been.

2 is a squirrel monkey (Chrysothrix). These small creatures have a long head, and a long tail which is not prehensile. It is a remarkable fact that the proportions of the skull, as compared with the face, are greater not only than in other monkeys, but even than in man himself.

3 is the head of an old male orang-utan. It has beautiful ears, and is in many ways very human.

4 is the bald-headed chimpanzee (female).

5 is one of the Burmese hairy men.

6 is Ardi, the last of the Kalangs, a low type of the human race from Java.

7 is one of the portraits of Cicero, the world's greatest orator, who was murdered by Antony's soldiers in the year 43 before Christ.

Now, the most interesting point of this group is to determine between which of the two figures occurs the greatest gap. Opinions will differ; but it is worth much thought, and probably few will say it is between the highest ape and the lowest man.

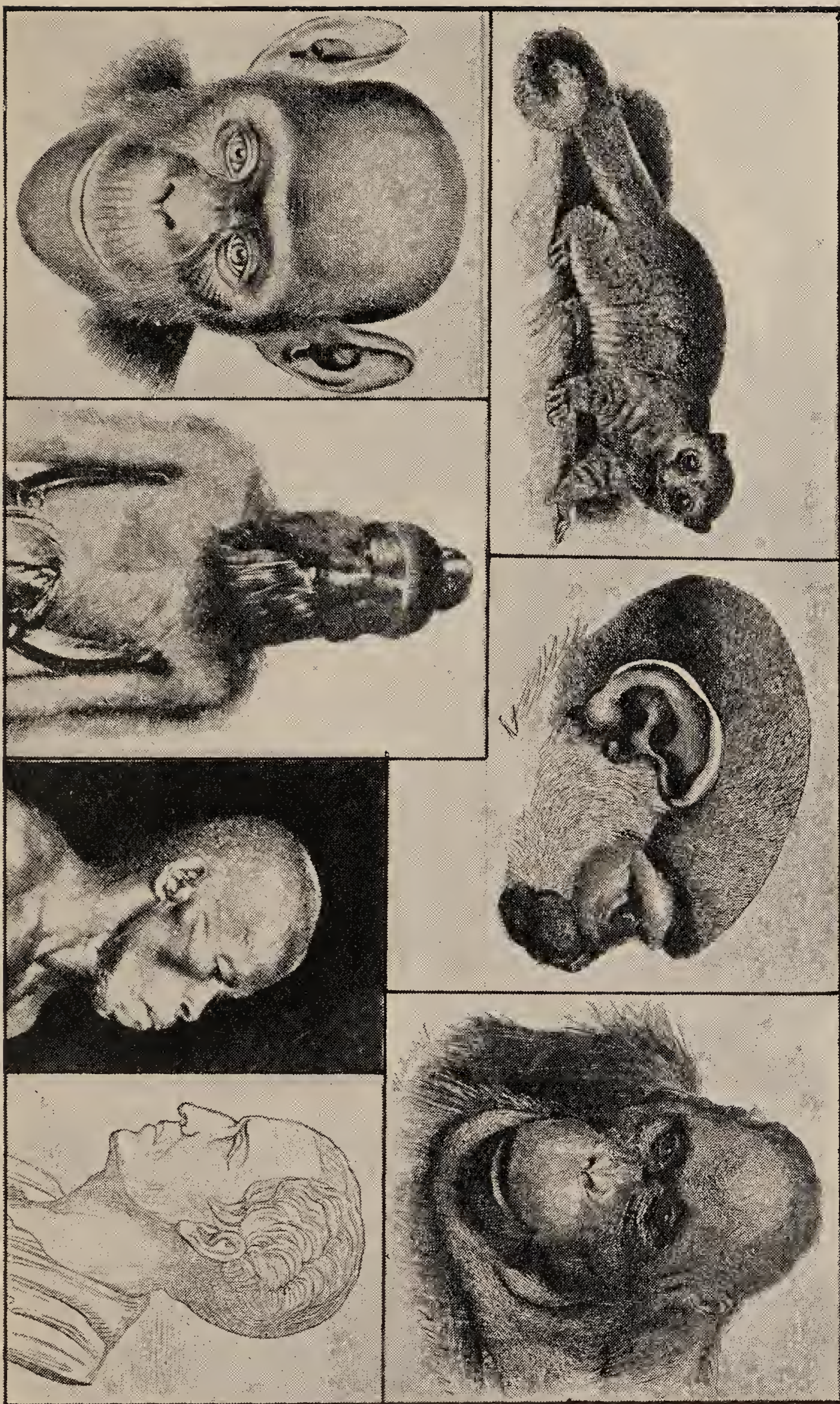

FIG. 182.—From Lemur to Cicero.

BOOKS RECOMMENDED.

First, on Evolution.—The beginner should master *A Picture Book of Evolution*, Parts I. and II., 2s. 6d. each net. He might then read *An Easy Outline of Evolution*, 2s. 6d. net. These should be followed by any of Mr. Edward Clodd's books. Several of the shilling books published by Newnes are excellent, especially *The Story of Plants*, *Birds*, *Reptiles*. The student should proceed by reading Darwin's *Origin of Species*, 6d., in the Rationalist Press Reprints; also in the same series, Huxley's *Lectures* and Haeckel's *Evolution of Man*. This last is the most marvellous book ever printed at the price. No one should neglect to read *The Study of Animal Life*, by Professor J. Arthur Thomson, 5s. This book contains a long list of valuable works for the student who wishes to take up any particular branch.

Second, on Astronomy.—Read Flammarion and Gore, already referred to; Sir Robert Ball's *The Earth's Beginning*, 7s. 6d.; Professor Young's *Manual of Astronomy*, 10s. 6d.; Newnes's *The Story of the Solar System* and *The Story of the Stars*, 1s. each.

Third, on Geology.—Professor Lapworth's *Intermediate Text-Book*, 5s.; Professor Grenville Cole's *Open-Air Studies*, 8s. 6d.; Professor Woodward's *Vertebrate Palæontology*, 14s.

Fourth, on Zoology.—*Zoology*, by Shipley and MacBride, 12s.; *Mammals*, by F. E. Beddard, 17s., in the great "Cambridge Natural History," which contains many other volumes of the utmost importance.

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